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DARLINGTON NGS 'A' STANDBY GENERATOR #3
VIBRATION ACCEPTANCE TESTS

Report No 89-5-K

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ABSTRACT

Commissioning tests to determine acceptability of Standby Generator #3 (AC generator and power turbine) dynamic and vibration characteristics are described. Vibration levels and structural dynamic characteristics of the AC generator are considered acceptable. The overall casing velocity and shaft displacement levels measured on the power turbine are acceptable. Impact tests on the power turbine structure/skid show a structural natural frequency close to the operating speed. A first rotor critical speed of the AC generator - power turbine unit between 1374 rpm and 1558 rpm, as well as another possible rotor critical close to 2900 rpm was identified. A theoretical rotor critical speed analysis of the unit is recommended to determine the rotor dynamic characteristics.

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EXECUTIVE SUMMARY

DARLINGTON NGS 'A' STANDBY GENERATOR #3 VIBRATION ACCEPTANCE TESTS

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Plant Equipment Dynamics Section
Mechanical Research Department

As part of the Darlington NGS commissioning program, acceptance tests were carried out on Standby Generator #3 to determine the vibration and dynamic characteristics of the AC generator and power turbine.

The overall bearing casing velocity and shaft displacement levels measured on the AC generator (at various loads) are considered acceptable. The structural dynamic characteristics of the AC generator are also considered acceptable.

The overall bearing casing velocity levels and shaft displacement levels measured on the power turbine are considered acceptable. Impact tests on the power turbine structure/skid show a natural frequency close to the operating speed (60 Hz). However, the 60 Hz velocity component is considered acceptable. It is recommended that velocity spectra be obtained on the power turbine periodically to assess the effect of the structural natural frequency.

A rotor first critical speed of the AC generator - power turbine unit between 1374 rpm and 1558 rpm, as well as another possible rotor critical close to 2900 rpm was identified. A theoretical rotor critical speed analysis of the AC generator - power turbine unit, to determine the rotor dynamic characteristics, is recommended. Relatively high shaft displacement levels were measured at the AC generator bearings while passing through the first critical during the cold start runup. It is recommended that the manufacturer indicate whether the levels are acceptable. Amplification factors while going through the first critical are considered acceptable.

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To

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Technical Manager
Darlington NGS 'A'

DARLINGTON NGS 'A' STANDBY GENERATOR #3 VIBRATION ACCEPTANCE TESTS

1.0 INTRODUCTION

Vibration acceptance tests were carried out on four Standby Generators SG #1 - SG #4, as part of the Darlington NGS 'A' commissioning program. Mechanical Research (Ontario Hydro) was requested to carry out the vibration commissioning program as specified by Pratt & Whitney and Darlington NGS 'A' Operations. This report discusses the results of the tests on Standby Generator #3. The results of the vibration acceptance tests on Standby Generators #1, #2 and #4 can be found in references 1, 2 and 3, respectively.

The principal objectives of the tests were to:

1) Evaluate the acceptability of the machine vibration and dynamic characteristics with respect to Pratt & Whitney's contractual obligations as well as Ontario Hydro's specifications and/or industry standards.

2) Obtain baseline vibration data for use in future machine monitoring.

3) Make recommendations for corrective action if vibration levels are in excess of the limits specified in the relevant tendering documents or specifications.

The general turbine-generator arrangement is shown in Figures 1, 2 and 3. The main components are the gas generator, the power turbine (Rolls Royce) and the AC generator (Brush) with a rated output of 27250 KVA at 3600 rpm.

This report presents the vibration data obtained on the power turbine and AC generator.

2.0 INSTRUMENTATION, TEST METHOD AND MEASUREMENTS

2.1 Instrumentation

The main components of the instrumentation used in obtaining the various measurements are listed in Table 1 and are further discussed in Sections 2.1.1 to 2.3, inclusive.

2.1.1 On-line Vibration Monitoring System

Each turbine-generator unit has an on-line vibration monitoring system which measures the overall vibration levels at selected locations on the gas generator, power turbine and AC generator. The permanently installed vibration transducers and their locations are outlined below :

1. AC Generator - The two journal bearings of the AC generator are equipped with two displacement transducers per bearing, mounted radially at 90 degrees to each other. These displacement transducers (Bently Nevada Model 21505-00-12-60-02) measure the generator shaft motion relative to the bearing housing.

2. Power Turbine - Two displacement transducers (Bently Nevada Model 21505-00-12-60-02) are mounted radially at 90 degrees to each other on each of the two journal bearings, and measure the power turbine shaft motion relative to the bearing housing.

A velocity transducer (Bell and Howell Type 4-103-0001) is also mounted vertically on an adapter plate bolted to the top of the bearing pedestal across the centre line of the power turbine inboard bearing and measures the power turbine inboard pedestal velocity.

3. Gas Generator - A velocity transducer (Bell and Howell Type 4-125-L209) is mounted vertically on the gas generator intermediate casing and measures the gas generator casing velocity.

The signals from the four displacement transducers (installed on the AC generator) and the two velocity transducers are monitored. The vibration amplitudes are displayed by the on-line vibration monitoring system. The shaft displacement amplitudes are measured in units of micrometers peak-peak; and the power turbine inboard bearing pedestal and gas generator intermediate casing velocities are measured in units of mm/s rms. The signals from the power turbine displacement transducers are not monitored by the on-line monitoring system.

2.1.2 Transducers used for Vibration Acceptance Tests

The permanently installed shaft displacement transducers at the AC generator and power turbine bearings in the X and Y directions (Figures 2, 4, 5 and 6) were utilized for the vibration acceptance tests. Their output signals were continuously monitored throughout the tests. The permanently installed velocity transducers were only periodically monitored.

Accelerometers were mounted on the power turbine inboard bearing casing and the AC generator bearing casings in the X, Y and axial directions (Figures 4 and 5) to measure the casing velocities. No velocity measurements were made on the power turbine outboard bearing casing or pedestal.

A photoelectric tachometer probe (Bruel & Kjaer MM 0024) was installed at the exciter end of the generator to provide a reference mark for phase angle and shaft speed measurements.

2.2 Test Method

The test procedure for the Standby Generator unit is outlined below :

1. The cold soaked (minimum 4 hours since last run) unit was started, synchronized and the load raised to full load for the ambient temperature, at the maximum allowable rate. The unit was held at full load for approximately one hour. All vibration signals were recorded on magnetic tape during runup and full load operating conditions. Synchronous speed is 3600 rpm (60 Hz).

2. The load was reduced at the maximum rate and the unit was shutdown.

3. The unit was restarted within 20 minutes of fuel shutoff (hot start) and the load raised to full load for the ambient temperature at the maximum allowable rate. Vibration signals were recorded during runup.

In order to evaluate the unit's vibration characteristics under different loads, the unit's power was decreased from 100% (maximum load attainable) to 0% (synchronous idle) in increments of approximately 25%. Loads of 26 MW (maximum load attained), 20 MW, 13 MW, 7 MW and 0 MW were selected. At each load, the unit was allowed to stabilize before the vibration signals were recorded.

4. From synchronous (3600 rpm) idle, the speed was reduced to the minimum power turbine controlled speed (approximately 88% synchronous speed) then increased slowly to the trip speed (approximately 110% synchronous speed). The unit was allowed to trip and rundown to zero speed. All vibration signals were continuously recorded during this period of speed changes.

5. Structural dynamics testing was carried out with the unit not running.

2.3 Measurements

2.3.1 Overall Vibration Levels

The bearing casing overall velocity levels were determined from accelerometer (Bruel & Kjaer Model 4368, Endevco Model 7707-1000) signals which were integrated to velocity and then analyzed with a Bently Nevada Digital Vector Filter (DVF 3). True peak and RMS overall velocity levels were measured.

Shaft overall displacement levels were obtained by analyzing the displacement transducer signals with the DVF 3.

2.3.2 Velocity and Displacement Spectra

Velocity and displacement spectra were generated from the accelerometer signals (integrated once) and displacement signals, respectively, by performing a Fast Fourier Transform (FFT) on the digitized signal.

2.3.3 Bode Plots

The shaft displacement and casing velocity signals recorded during the periods of unit runup and rundown were analyzed using a computer managed data acquisition and analysis system developed by Mechanical Research, Ontario Hydro. Bearing housing velocity and shaft displacement magnitude and phase, at filtered 1 x shaft rotating frequency, versus generator shaft speed were calculated and plotted (Bode plot).

The Bode plots which show the rotor or casing response in both amplitude and phase as a function of shaft rotor speed were used to identify the rotor and structural natural frequencies of the AC generator and power turbine.

Bode plots produced using shaft displacement transducer signals may be inaccurate if the signal from the transducer includes any appreciable amount of shaft bow or runout (ie, any deviation in the shaft surface which produces a transducer output which is not related to shaft vibration). For this reason, both uncompensated and compensated (ie, compensated for bow and runout by subtracting the slowroll vector from the displacement vector) Bode plots were produced. Compensation is further discussed in Appendix A.

2.3.4 RPM Spectral Maps

Displacement and velocity spectra were generated from the transducer signals at various periods during runup and reproduced as a three-dimensional RPM spectral map.

2.3.5 Impact Spectra

AC generator and power turbine structural natural frequencies were determined by impact testing. With the unit not running, the AC generator and power turbine structures were excited throughout a range of frequencies (5-500 Hz) with a hammer having an elastomeric tip and instrumented with a force transducer. The input force (hammer) and the motor response (accelerometer signal) signals were fed simultaneously into a dual channel FFT analyzer (Ono Sokki CF 920) which calculated the input and response spectra as well as the compliance transfer function. The validity of the transfer function was checked by the coherence of the input and response signals. The ambient noise was reduced by averaging the results of eight impacts.

All impact tests were performed when the unit was cold and not running.

3.0 RESULTS AND DISCUSSION

3.1 Overall Casing Velocity and Velocity Spectra

Overall casing velocity measured on the AC generator and power turbine at the various loads from 0 to 26 MW are summarized in Table 2 and Table 3, respectively. According to the Darlington NGS tendering document, the lateral vibration level measured on the bearing housings should not exceed 2.8 mm/s rms for acceptance purposes.

All overall velocity levels were obtained from the unfiltered (5 Hz - 1000 Hz) velocity signals.

3.1.1 AC Generator - Overall Casing Velocity and Velocity Spectra

The maximum overall velocity was measured on the inboard bearing casing (X-direction) at loads of 20 MW and 26 MW (Table 2) and is 0.6 mm/s rms. Overall velocity vibration levels measured on the AC generator bearing casings are considered acceptable.

Velocity spectra obtained at the six measurement locations on the AC generator for the various loads are shown in Figures 7 - 36 (Table 6). These spectra show that the main frequency components are at 1 x, 2 x and 3 x synchronous frequency. The vibration amplitudes at these frequencies are considered acceptable. The velocity levels at 1 x and 2 x synchronous frequency are listed in Table 2.

3.1.2 Power Turbine - Overall Casing Velocity and Velocity Spectra

Velocity measurements on the power turbine were made only at the inboard bearing casing. The maximum overall RMS velocity measured on the bearing housing is 1.8 mm/s and was obtained in the axial direction at 13 MW (Table 3). The maximum peak velocity is 5.5 mm/s and was also measured in the axial direction at 13 MW. The inboard bearing casing overall velocity levels are considered acceptable. Velocity levels at 1 x and 2 x synchronous frequency are listed in Table 3.

Velocity spectra obtained on the power turbine inboard bearing housing at the various loads are shown in Figures 37 - 51 (Table 7). These spectra show that the main frequency components are at 60 Hz and between 14 Hz and 19.5 Hz. The peaks in the 14 Hz to 19.5 Hz spectral band are most likely due to broadband excitation of the system natural frequencies.

3.2 Overall Shaft Displacement and Displacement Spectra

Overall shaft relative displacement levels measured on the AC generator and power turbine at various loads from 0 to 26 MW are summarized in Table 4 and Table 5, respectively. According to the Darlington NGS tendering document, the maximum vibration of the shaft relative to the bearing casing should not exceed 60 micrometers peak to peak for acceptance purposes.

The sensitivity of the displacement transducers is 7.87 millivolts/micrometer. All overall shaft displacement levels were obtained from the unfiltered (5 Hz - 1000 Hz) signals.

3.2.1 AC Generator - Overall Shaft Displacement and Displacement Spectra

The maximum overall displacement level measured is 32 μm p-p and was obtained at the inboard bearing (Y-direction) at loads of 0 MW and 7 MW (Table 4). Overall shaft displacement levels measured on the AC generator are considered acceptable.

Shaft displacement spectra obtained on the AC generator for the various loads are shown in Figures 52 - 71 (Table 6). These spectra show that the main frequency components are at 60 Hz and 120 Hz. The displacement levels at these two frequencies are listed in Table 4.

3.2.2 Power Turbine - Overall Shaft Displacement and Displacement Spectra

The maximum overall displacement level measured is 58 μm p-p and was obtained at the outboard bearing in the Y-direction at a load of 7 MW, and in the X-direction at a load of 20 MW (Table 5). Overall shaft displacement levels measured on the power turbine are considered acceptable.

Shaft displacement spectra obtained on the power turbine for the various loads are shown in Figures 72 - 91 (Table 7). In addition to the main frequency components at 1 x and/or 2 x synchronous frequency, these spectra show a broad band response below 60 Hz. This response is most likely due to a broad band excitation (possibly due to flow through the turbine) of the system natural frequencies.

The displacement levels at 1 x and 2 x synchronous frequency are listed in Table 5.

3.3 Cold Start Runup

3.3.1 AC Generator - Cold Start Runup

Figures 92 - 101 (Table 6) show the 1 x RPM filtered bode plots (500 rpm to 3600 rpm) of the AC generator velocity and displacement levels obtained during the cold start runup. Compensated and uncompensated bode plots are shown for the shaft displacement signals. A slow roll vector at approximately 500 rpm is used for compensation.

The bode plots of the filtered shaft displacements and casing velocities (X and Y directions) show a first rotor critical speed at 1558 rpm (26.0 Hz). Bode plots of the inboard and outboard bearing casing velocities in the X-direction (Figures 92 and 95) also show a peak in the response at 2070 rpm (34.5 Hz) due to the presence of a structural natural frequency close to 35 Hz. Impact spectra obtained on the generator outboard bearing casing in the axial and vertical directions (Figures 178 and 179) show a structural natural frequency at 35 Hz.

The filtered (1 x RPM) velocity levels measured on the inboard and outboard bearing casings during the runup (Figures 92 - 97) do not exceed 1.7 mm/s peak. The maximum filtered compensated shaft displacement level occurs while passing through the first rotor critical speed at 1558 rpm (Figures 98 - 101). Maximum filtered compensated shaft displacements of approximately 90 μm p-p and 85 μm p-p were measured at the outboard bearing (Y-direction, Figure 98) and inboard bearing (Y-direction, Figure 100), respectively, while passing through the critical. Amplification factors while accelerating through the first critical were calculated from the four shaft displacement bode plots. Appendix B describes how amplification factors are determined. The calculated amplification factors range from 3.4 to 4.1 (depending on the measurement location and direction) and are considered acceptable. The American Petroleum Institute Standard 616 recommends that amplification factors should not exceed 8 while going through criticals; factors less than 5 are preferred/4/.

3.3.2 Power Turbine - Cold Start Runup

Figures 102 - 108 (Table 7) show the 1 x RPM filtered bode plots (500 rpm to 3600 rpm) of the power turbine velocity and displacement levels obtained during the cold start runup. Compensated and uncompensated bode plots are shown for the shaft displacement signals. A slow roll vector at approximately 500 rpm is used for compensation.

The filtered (1 x RPM) velocity levels measured on the inboard bearing casing in the three measured directions (X, Y and axial, Figures 102 - 104) do not exceed 4.5 mm/s peak during the runup. The filtered compensated shaft displacement levels (Figures 105 - 108) do not exceed 24 μm p-p during the runup.

The bode plots of the filtered casing velocities show peaks in the response at 996 rpm (16.6 Hz, Figures 103 and 104), 1096 rpm (18.3 Hz, Figure 102), 2270 rpm (37.8 Hz, Figure 104), and 2450 rpm (40.8 Hz, Figure 104). These peaks are due to amplification of the casing response by structural natural frequencies. Impact spectra obtained on the power turbine inboard and outboard bearing pedestals (Figures 182 - 184), as well as impact spectra obtained on other similar standby generator units at the Darlington Generating Station /1,2,3/ show structural natural frequencies close to these frequencies of peak response.

The bode plots of the shaft relative displacements (Figures 105- 108) also show peaks in the response at speeds corresponding to structural natural frequencies as discussed above. Figures 105 and 106 show a small peak in the response at approximately 1560 rpm. As noted in Section 3.3.1, this speed is the first rotor critical speed encountered during the generator runup.

3.4 Hot Start Runup

Bode plots (filtered 1 x RPM) and RPM spectral maps of the casing velocities and shaft displacements measured on the AC generator and power turbine during the hot start runup, are discussed in the following subsections.

Compensated and uncompensated bode plots are shown for the shaft displacement signals. The slow roll vector at approximately 500 rpm is used for compensation. The bode plots show the 1 x RPM filtered amplitude and phase from approximately 500 rpm to overspeed. This runup speed range was achieved by combining the hot start runup (0 rpm - 3600 rpm) with the runup from 3600 rpm to overspeed (Section 2.2). There was a time lapse of approximately 2 hours between the two runups.

3.4.1 AC Generator - Hot Start Runup

Figures 109 - 118 (Table 6) show the 1 x RPM filtered bode plots of the AC generator velocity and displacement levels obtained during the hot start runup.

The filtered (1 x RPM) velocity levels measured on the inboard and outboard bearing casings in the three directions (Figures 109 - 114) do not exceed 1.2 mm/s peak during the runup. The maximum filtered compensated shaft displacement occurs while passing through the first rotor critical speed at 1374 rpm (Figures 115 - 118). Maximum filtered shaft displacements (compensated) of approximately 62 μm p-p and 80 μm p-p were measured at the outboard bearing (Y-direction, Figure 115) and inboard bearing (Y-direction, Figure 117), respectively, while passing through the critical. Amplification factors for the first critical, calculated from the four shaft displacement bode plots (hot runup), range from 3.7 to 4.7 and are considered acceptable.

The difference between the hot start rotor first critical speed (1374 rpm) and the cold start first critical (1558 rpm) can most likely be attributed to temperature effects (different rotor and bearing oil temperatures) which may alter the rotor dynamic characteristics.

The peak in the response between 1924 rpm and 2122 rpm is due to the presence of a structural natural frequency as discussed in Section 3.3.1.

RPM spectral maps of the bearing casing velocities and shaft displacements (uncompensated) obtained during the hot start runup are shown in Figures 126 - 135 (Table 6).

3.4.2 Power Turbine - Hot Start Runup

Figures 119 - 125 (Table 7) show the 1 x RPM filtered bode plots of the power turbine velocity and displacement levels during the hot start runup.

The filtered (1 x RPM) velocity levels measured on the inboard bearing casing (Figures 119 - 121) do not exceed 1.2 mm/s peak during the runup. The filtered compensated shaft displacement levels measured at the inboard and outboard bearings (Figures 122 - 125) do not exceed 32 μm p-p.

RPM spectral maps of the bearing casing velocities and shaft displacements (uncompensated) obtained during the hot start runup are shown in Figures 136 - 142 (Table 7).

3.5 Rundown From Overspeed

Bode plots (filtered 1 x RPM) and RPM spectral maps of the casing velocities and shaft displacements measured on the AC generator and power turbine during the rundown from overspeed (3900 rpm approximately), are discussed in the following subsections. The rundown from overspeed follows the hot start and incremental load changes (Section 2.2 Item 4).

Compensated and uncompensated bode plots are shown for the shaft displacement signals. The slow roll vector at approximately 500 rpm is used for compensation.

3.5.1 AC Generator - Rundown From Overspeed

Figures 143 - 152 (Table 6) show the 1 x RPM filtered bode plots of the AC generator casing velocities and shaft displacements obtained during the rundown.

The filtered (1 x RPM) velocity levels measured on the inboard and outboard bearing casings in the three directions (X, Y and axial, Figures 143 - 148) do not exceed 1.6 mm/s peak during the rundown. The maximum filtered compensated shaft displacement occurs while passing through the first rotor critical speed at 1416 rpm (Figures 149 - 152). Maximum filtered shaft displacements (compensated) of approximately 67 μm p-p and 83 μm p-p were measured at the outboard bearing (Y-direction, Figure 149) and inboard bearing (Y-direction, Figure 151), respectively, while passing through the critical. Amplification factors for the first critical, calculated from the four shaft responses on rundown, range from 5.1 to 5.4 and are considered acceptable.

The bode plots show a first rotor critical speed close to 1416 rpm (23.6 Hz). The difference between the rotor first critical speed on runup (1374 rpm, Section 3.4.1) versus rundown (1416 rpm) is not unusual for rotors supported in hydrodynamic bearings.

RPM spectral maps of the bearing casing velocities and shaft displacements (uncompensated) obtained during the rundown are shown in Figures 160 - 169 (Table 6).

3.5.2 Power Turbine - Rundown From Overspeed

Figures 153 - 159 (Table 7) show the 1 x RPM filtered bode plots of the power turbine velocity and displacement levels obtained during the rundown.

The filtered (1 x RPM) velocity levels measured on the inboard bearing casing (Figures 153 - 155) do not exceed 1.7 mm/s peak during the rundown. The filtered compensated shaft displacement levels measured at the inboard and outboard bearings (Figures 156 -159) do not exceed 26 μm p-p.

The peak in the response close to 3700 rpm, shown on the casing velocity bode plots obtained during rundown (Figures 153 and 154), is most likely due to the presence of a structural natural frequency close to 60 Hz. An impact spectrum obtained on the turbine inboard bearing pedestal in the vertical direction (Figure 183) shows the structural natural frequency at 60 Hz. The bode plot of the inboard shaft displacement in the X-direction (Figure 156) shows the rotor critical speed at 1414 rpm.

RPM spectral maps of the bearing casing velocities and shaft displacements (uncompensated) obtained during the rundown are shown in Figures 170 - 176 (Table 7).

3.6 Structural Natural Frequencies

3.6.1 AC Generator - Structural Natural Frequencies

Compliance transfer function spectra obtained on the AC generator outboard and inboard bearing casings in the horizontal, vertical and axial directions are shown in Figures 177 - 181. These impact spectra show no structural natural frequencies close to the synchronous speed (60 Hz) or to twice the synchronous speed.

3.6.2 Power Turbine - Structural Natural Frequencies

Compliance transfer function spectra obtained on the power turbine structure and skid from impact testing are shown in Figures 182 - 186. Impact spectra obtained on the power turbine inboard bearing pedestal (vertical direction, Figure 183) and on the inboard end of the power turbine skid (vertical direction, Figure 186) show a structural natural frequency at the synchronous speed (60 Hz). Structural natural frequencies appear to be sufficiently removed from 2 x synchronous speed.

Structural natural frequencies at or close to synchronous speed are generally considered unacceptable since they can amplify the casing response significantly, unless the mode is sufficiently damped.

The 60 Hz component of the power turbine velocities measured at the inboard and outboard bearing casings (Table 3) is considered acceptable. However, the vibration amplitude at 60 Hz is dependent on the level of excitation at this frequency. Should this excitation increase in the future (most likely due to increased unbalance), amplification of the casing response by the structural natural frequency may result in unacceptable levels of vibration.

3.7 Rotor Natural Frequencies / Critical Speeds

The first rotor critical speed of the AC generator - power turbine unit, identified during runup and rundown (Sections 3.3 to 3.5.2) lies between 1374 rpm (22.9 Hz) and 1558 rpm (26.0 Hz). No other rotor critical speeds within the speed range from zero to overspeed were positively identified from the runup and rundown tests. However, bode plots of the power turbine inboard shaft displacement obtained during the cold start runup and hot rundown from overspeed show a peak in the rotor response close to 2900 rpm (Figures 105, 106, 156 and 157), and may indicate a second rotor critical speed.

4.0 CONCLUSIONS

4.1 The overall shaft displacement and bearing casing velocity levels measured on the AC generator, at five loads ranging from 0 MW to 26 MW, are considered acceptable.

4.2 The overall velocity levels measured on the power turbine inboard bearing casing, at five loads ranging from 0 MW to 26 MW, are acceptable. The overall shaft displacement levels measured at the inboard and outboard bearings of the power turbine are considered acceptable.

4.3 The maximum filtered (1 x RPM) compensated shaft displacement measured at the inboard and outboard bearings of the power turbine during runup and rundown, does not exceed 32 μm p-p.

4.4 The AC generator's maximum filtered shaft displacement occurred while passing through the first rotor critical (1374 rpm - 1558 rpm). Maximum filtered shaft displacements (compensated) of approximately 90 μm p-p and 85 μm p-p were measured at the outboard and inboard bearings, respectively, while passing through the critical and occurred during the cold start runup. These levels are considered relatively high.

Amplification factors (AC generator) while passing through the first critical during cold start runup, hot start runup and hot rundown range from 3.4 to 5.4 and are considered acceptable.

4.5 Structural dynamics testing of the AC generator indicates that all structural natural frequencies are sufficiently removed from the synchronous speed (60 Hz) and twice the synchronous speed.

4.6 Structural dynamics testing of the power turbine shows a structural natural frequency of the power turbine structure/skid close to the synchronous speed. The velocity levels measured on the power turbine bearing casing are presently acceptable. However, increased levels of excitation at the synchronous frequency (most likely due to unbalance) combined with the possible amplification of the casing response by the structural natural frequency could result in unacceptable levels of vibration.

4.7 The first rotor critical speed of the AC generator - power turbine unit, identified during runup and rundown, is between 1374 rpm (22.9 Hz) and 1558 rpm (26 Hz). Another possible rotor critical speed close to 2900 rpm was identified. No other rotor critical speeds within the speed range from zero to overspeed were positively identified from the runup and rundown tests.

5.0 RECOMMENDATIONS

5.1 It is recommended that velocity spectra be obtained on the power turbine inboard and outboard bearing pedestals periodically to obtain a trend of the 60 Hz component. If the 60 Hz component increases significantly, remedial action should be taken. Detuning the structural natural frequency near the synchronous speed would be one possible solution.

5.2 It is recommended that a theoretical rotor critical speed analysis of the AC generator - power turbine unit be carried out to determine the rotor dynamic characteristics.

5.3 Since the standby generators are routinely started up and may experience numerous starts during the life of the plant, it is recommended that the manufacturer indicate whether the relatively high shaft displacement levels measured on the AC generator during the cold start runup are acceptable.

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REFERENCES

1. N. Jagan, P. Hoogendam, "Darlington NGS 'A' Standby Generator #1 - Vibration Acceptance Tests", Ontario Hydro Research Division Report No. 88-241-K, 1988.

2. N. Jagan, P. Hoogendam, "Darlington NGS 'A' Standby Generator #2 - Vibration Acceptance Tests", Ontario Hydro Research Division Report No. 89-4-K, 1989.

3. N. Jagan, P. Hoogendam, "Darlington NGS 'A' Standby Generator #4 - Vibration Acceptance Tests", Ontario Hydro Research Division Report No. 89-6-K, 1989.

4. "Type H Industrial Combustion Gas Turbines for Refinery Services", API Standard 616, 2nd Ed, June 1982.

TABLE 1
INSTRUMENTATION LIST

1. Accelerometer	Bruel & Kjaer Model 4368
2. Accelerometer	Endevco Model 7707-1000
3. Displacement Transducer	Bently Nevada Model 21505-00-12-60-02
4. Charge Amplifier	Bruel & Kjaer Model 2635
5. Displacement Transducer Amplifier	Ontario Hydro Research
6. Photoelectric Tachometer Probe	Bruel & Kjaer MM 0024
7. Dual Channel Analyzer	Ono Sokki CF 920
8. Digital Plotter	Hewlett-Packard Model 7470A
9. Laserjet Printer	Texas Instruments - Omnilaser 2108
10. Oscilloscope	Tektronix Model 2215
11. Tape Recorder	Honeywell Model 101
12. Filter	Krohn-Hite Model 3343
13. Vibration Calibrator	General Radio Model 1557-A
14. Digital Vector Filter	Bently Nevada DVF 2
15. Instrumented Tip Impact Hammer	PCB Piezotronics Inc, Model 086B50
16. Personal Microcomputer	IBM-PC AT

TABLE 2

DARLINGTON GS 'A' STANDBY GENERATOR #3
AC GENERATOR 1 x SYNCHRONOUS, 2 x SYNCHRONOUS AND OVERALL CASING VELOCITY LEVELS

	AC Generator Outboard Bearing Casing Velocity X - Direction				AC Generator Outboard Bearing Casing Velocity Y - Direction				AC Generator Outboard Bearing Casing Velocity Axial Direction			
Load (MW)	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk
0	0.18	0.41	0.4	0.7	0.17	0.43	0.4	0.8	0.22	0.14	0.3	0.6
7	0.17	0.37	0.3	0.7	0.20	0.41	0.4	0.7	0.22	0.16	0.3	0.5
13	0.14	0.29	0.3	0.6	0.19	0.29	0.3	0.6	0.22	0.13	0.4	0.6
20	0.11	0.21	0.3	0.6	0.16	0.29	0.3	0.6	0.22	0.16	0.3-0.4	0.6-0.7
26	0.12	0.22	0.3	0.6	0.16	0.27	0.3	0.6	0.23	0.14	0.3-0.4	0.7-0.9

	AC Generator Inboard Bearing Casing Velocity X - Direction				AC Generator Inboard Bearing Casing Velocity Y - Direction				AC Generator Inboard Bearing Casing Velocity Axial Direction			
Load (MW)	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk
0	0.17	0.46	0.4	0.7	0.23	0.32	0.3	0.7	0.14	0.18	0.2	0.5
7	0.17	0.53	0.4	0.8	0.23	0.33	0.3	0.6	0.11	0.12	0.2	0.4
13	0.15	0.59	0.4	0.9	0.23	0.46	0.4	0.8	0.10	0.06	0.2	0.4
20	0.13	0.79	0.6	1.2	0.23	0.52	0.5	1.1	0.08	0.07	0.3	0.6
26	0.12	0.79	0.6	1.2	0.24	0.54	0.5	1.1	0.09	0.08	0.2	0.6

TABLE 3

DARLINGTON GS 'A' STANDBY GENERATOR #3
POWER TURBINE 1 x SYNCHRONOUS, 2 x SYNCHRONOUS AND OVERALL CASING VELOCITY LEVELS

	Power Turbine Inboard Bearing Casing Velocity X - Direction				Power Turbine Inboard Bearing Casing Velocity Y - Direction				Power Turbine Inboard Bearing Casing Velocity Axial Direction			
Load (MW)	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (60 Hz) mm/s pk	2 x Sync (120 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk
0	0.79	0.20	1.0-1.4	2.0-3.8	0.88	0.10	0.9-1.1	1.5-2.2	0.08	0.07	1.1-1.6	2.0-3.8
7	0.61	0.32	1.1-1.6	1.7-4.0	0.79	0.10	0.9-1.2	1.5-2.5	0.07	0.05	0.9-1.5	1.8-2.5
13	0.24	0.40	1.0-1.4	2.1-2.8	0.45	0.13	0.8-0.9	1.3-2.3	0.08	0.07	1.0-1.8	4.7-5.5
20	0.32	0.52	0.9-1.1	1.8-2.4	0.24	0.16	0.7	1.4-2.1	0.08	0.09	1.2-1.4	2.2-4.0
26	0.44	0.51	0.9-1.1	1.9-2.3	0.39	0.17	0.7-0.9	1.4-2.0	0.13	0.10	1.2-1.4	2.2-3.0

TABLE 4

DARLINGTON GS 'A' STANDBY GENERATOR #3
AC GENERATOR 1 x SYNCHRONOUS, 2 x SYNCHRONOUS, AND OVERALL SHAFT RELATIVE DISPLACEMENT LEVELS

	AC Generator Outboard Bearing Shaft Displacement X - Direction (µm p-p)			AC Generator Outboard Bearing Shaft Displacement Y - Direction (µm p-p)			AC Generator Inboard Bearing Shaft Displacement X - Direction (µm p-p)			AC Generator Inboard Bearing Shaft Displacement Y - Direction (µm p-p)		
Load (MW)	1 x Sync (60 Hz)	2 x Sync (120 Hz)	Overall	1 x Sync (60 Hz)	2 x Sync (120 Hz)	Overall	1 x Sync (60 Hz)	2 x Sync (120 Hz)	Overall	1 x Sync (60 Hz)	2 x Sync (120 Hz)	Overall
0	16.3	12.8	25	13.4	17.0	30	13.9	6.8	31	17.7	3.8	32
7	15.5	12.5	24	12.1	16.8	29	14.0	6.7	30	17.8	3.1	32
13	14.7	12.1	23	11.8	16.3	28	13.7	6.6	31	17.9	3.2	31
20	14.5	11.8	22	12.5	15.9	27	13.3	6.3	30	17.6	3.2	31
26	14.3	11.7	22	12.1	16.0	28	13.2	6.4	29	17.0	3.3	30

TABLE 5

DARLINGTON GS 'A' STANDBY GENERATOR #3
POWER TURBINE 1 x SYNCHRONOUS, 2 x SYNCHRONOUS, AND OVERALL SHAFT RELATIVE DISPLACEMENT LEVELS

	Power Turbine Inboard Bearing Shaft Displacement X - Direction (μm p-p)			Power Turbine Inboard Bearing Shaft Displacement Y - Direction (μm p-p)			Power Turbine Outboard Bearing Shaft Displacement X - Direction (μm p-p)			Power Turbine Outboard Bearing Shaft Displacement Y - Direction (μm p-p)		
Load (MW)	1 x Sync (60 Hz)	2 x Sync (120 Hz)	Overall	1 x Sync (60 Hz)	2 x Sync (120 Hz)	Overall	1 x Sync (60 Hz)	2 x Sync (120 Hz)	Overall	1 x Sync (60 Hz)	2 x Sync (120 Hz)	Overall
0	12.4	9.2	36 - 46	19.3	9.6	41 - 57	1.5	6.4	14 - 17	6.6	7.3	28 - 37
7	21.3	9.5	37 - 50	21.6	9.4	37 - 58	2.8	6.3	11 - 16	7.8	6.9	31 - 44
13	25.9	9.6	39 - 42	21.3	9.4	35 - 47	3.0	6.3	13 - 15	6.8	6.7	23 - 48
20	29.4	9.9	47 - 58	21.1	9.2	36 - 41	3.2	6.3	10 - 15	6.0	6.6	20 - 30
26	31.6	10.0	47 - 62	21.7	9.3	35 - 40	3.6	6.4	11 - 14	5.9	6.6	22 - 32

TABLE 6

DARLINGTON GS 'A' STANDBY GENERATOR #3 - AC GENERATOR
FIGURE NUMBERS OF VIBRATION SPECTRA, BODE PLOTS AND RPM SPECTRAL MAPS

Measurement		FFT Spectrum Figure No. Load (MW)					Bode Plot Cold Start Runup Figure No.	Bode Plot Hot Start Runup Figure No.	RPM Spectral Map Hot Start Runup Figure No.	Bode Plot Rundown from Overspeed Figure No.	RPM Spectral Map Rundown from Overspeed Figure No.
		0	7	13	20	26					
Outboard Bearing Casing Velocity	X - Direction	7	13	19	25	31	92	109	126	143	160
	Y - Direction	8	14	20	26	32	93	110	127	144	161
	Axial	9	15	21	27	33	94	111	128	145	162
Inboard Bearing Casing Velocity	X - Direction	10	16	22	28	34	95	112	129	146	163
	Y - Direction	11	17	23	29	35	96	113	130	147	164
	Axial	12	18	24	30	36	97	114	131	148	165
Outboard Bearing Shaft Displacement	Y - Direction	52	56	60	64	68	100	115	132	149	166
	X - Direction	53	57	61	65	69	101	116	133	150	167
Inboard Bearing Shaft Displacement	Y - Direction	54	58	62	66	70	98	117	134	151	168
	X - Direction	55	59	63	67	71	99	118	135	152	169

TABLE 7

DARLINGTON GS 'A' STANDBY GENERATOR #3 - POWER TURBINE
FIGURE NUMBERS OF VIBRATION SPECTRA, BODE PLOTS AND RPM SPECTRAL MAPS

Measurement		FFT Spectrum Figure No. Load (MW)					Bode Plot Cold Start Runup Figure No.	Bode Plot Hot Start Runup Figure No.	RPM Spectral Map Hot Start Runup Figure No.	Bode Plot Rundown from Overspeed Figure No.	RPM Spectral Map Rundown from Overspeed Figure No.
		0	7	13	20	26					
Inboard Bearing Casing Velocity	X - Direction	37	40	43	46	49	102	119	136	153	170
	Y - Direction	38	41	44	47	50	103	120	137	154	171
	Axial	39	42	45	48	51	104	121	138	155	172
Inboard Bearing Shaft Displacement	X - Direction	72	76	80	84	88	105	122	139	156	173
	Y - Direction	73	77	81	85	89	106	123	140	157	174
Outboard Bearing Shaft Displacement	X - Direction	74	78	82	86	90	107	124	141	158	175
	Y - Direction	75	79	83	87	91	108	125	142	159	176

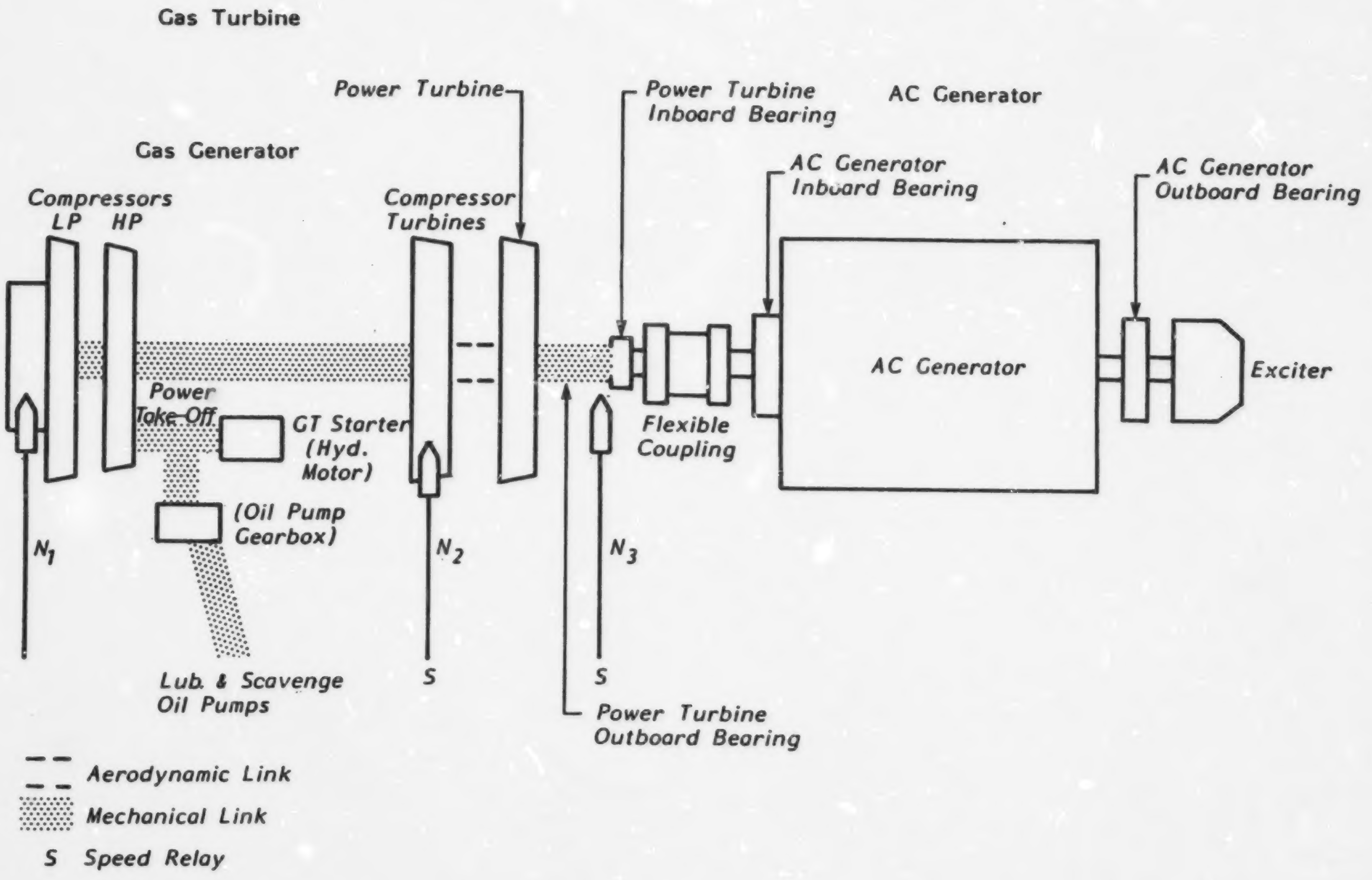


FIGURE 1

DARLINGTON NGS STANDY TURBINE-GENERATOR SYSTEM

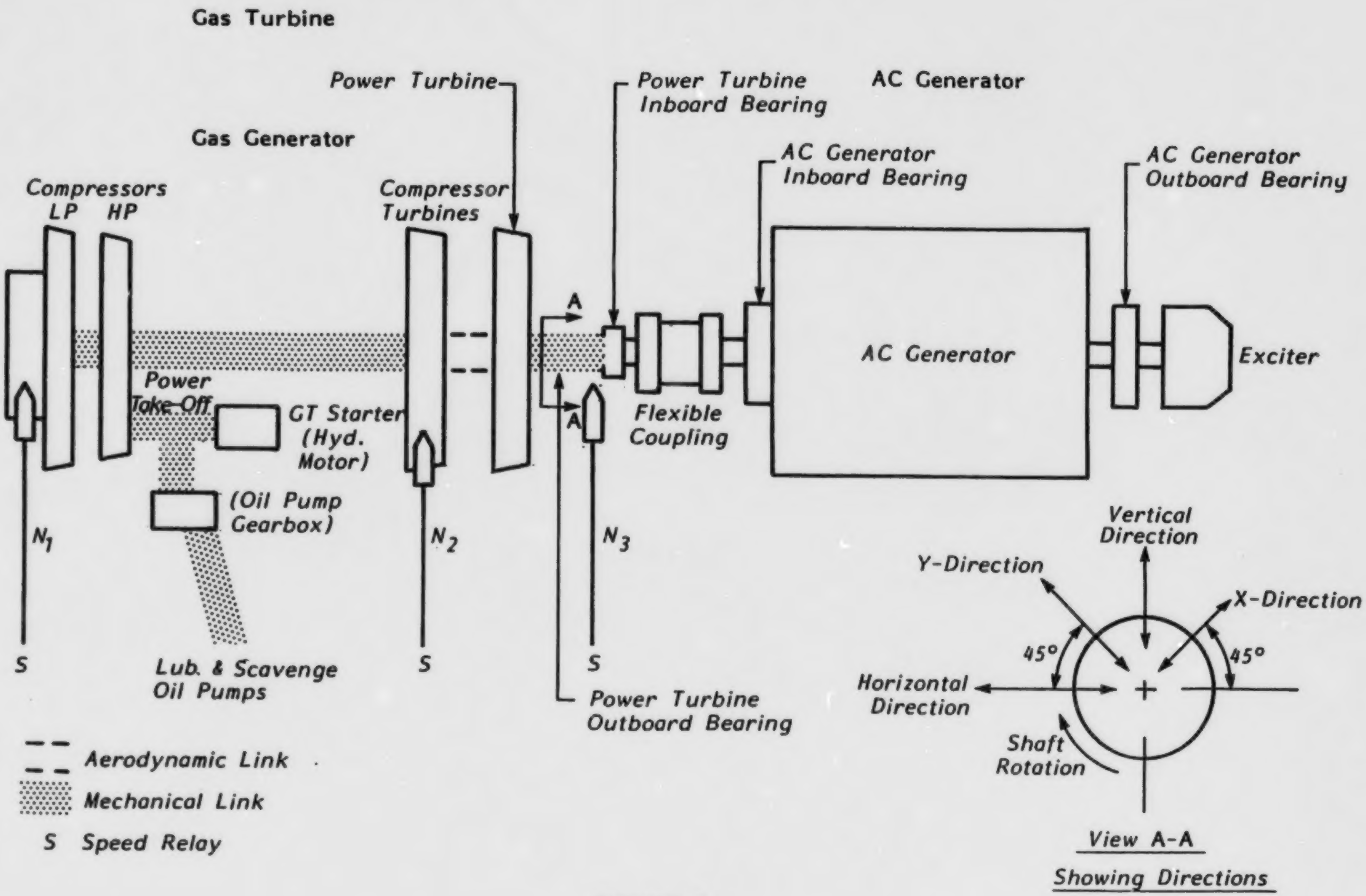
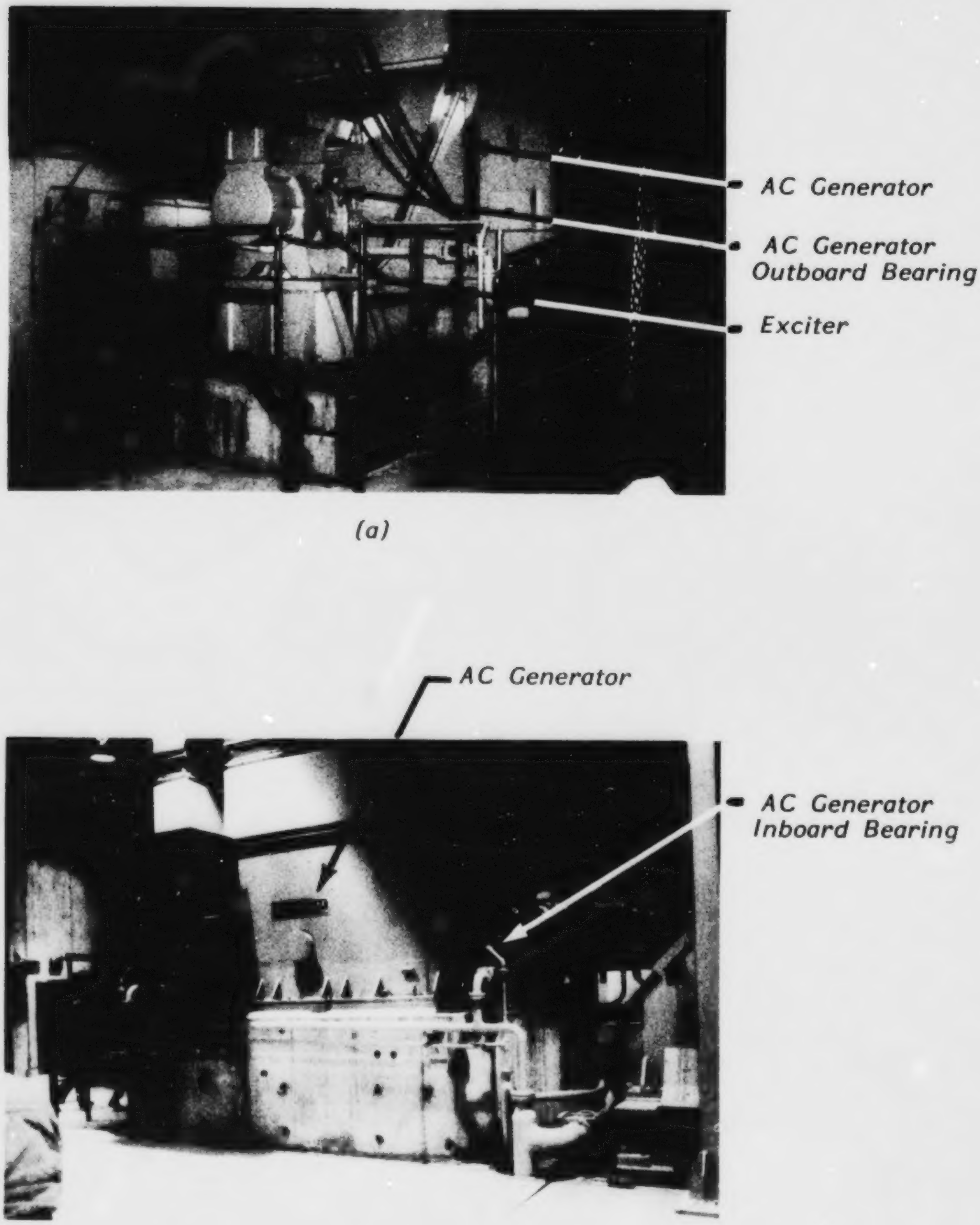


FIGURE 2

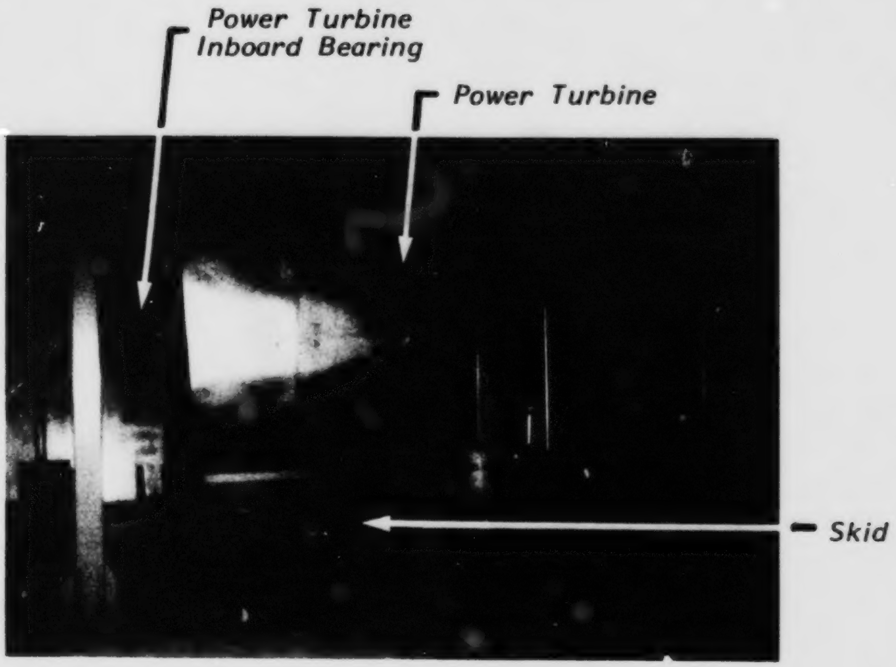
DARLINGTON NGS STANDBY TURBINE-GENERATOR SYSTEM
SHOWING MEASUREMENT DIRECTIONS



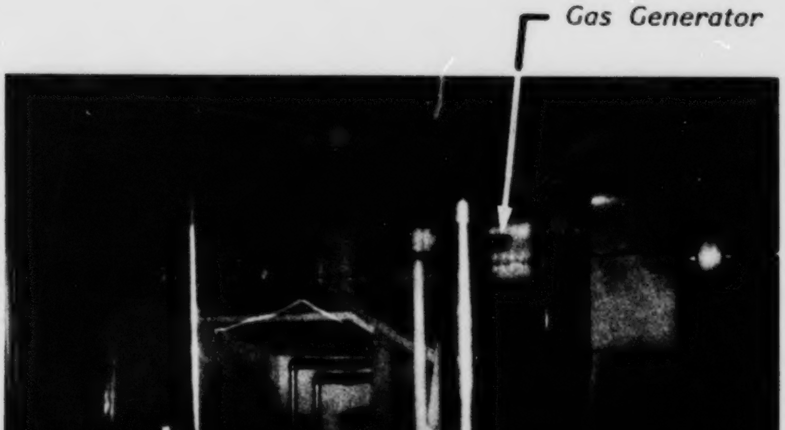
(a)

(b)

FIGURES 3(a) & (b)
LAYOUT OF STANDBY GENERATOR SYSTEM

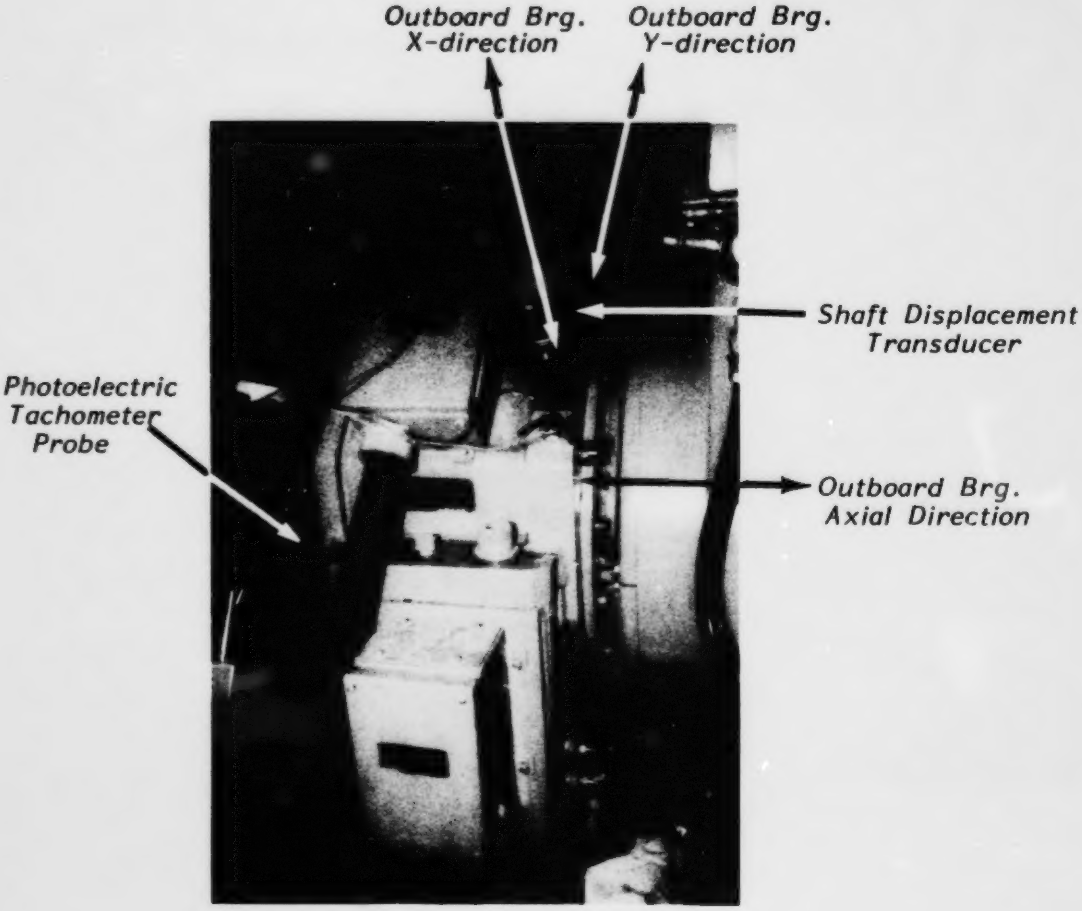


(c)

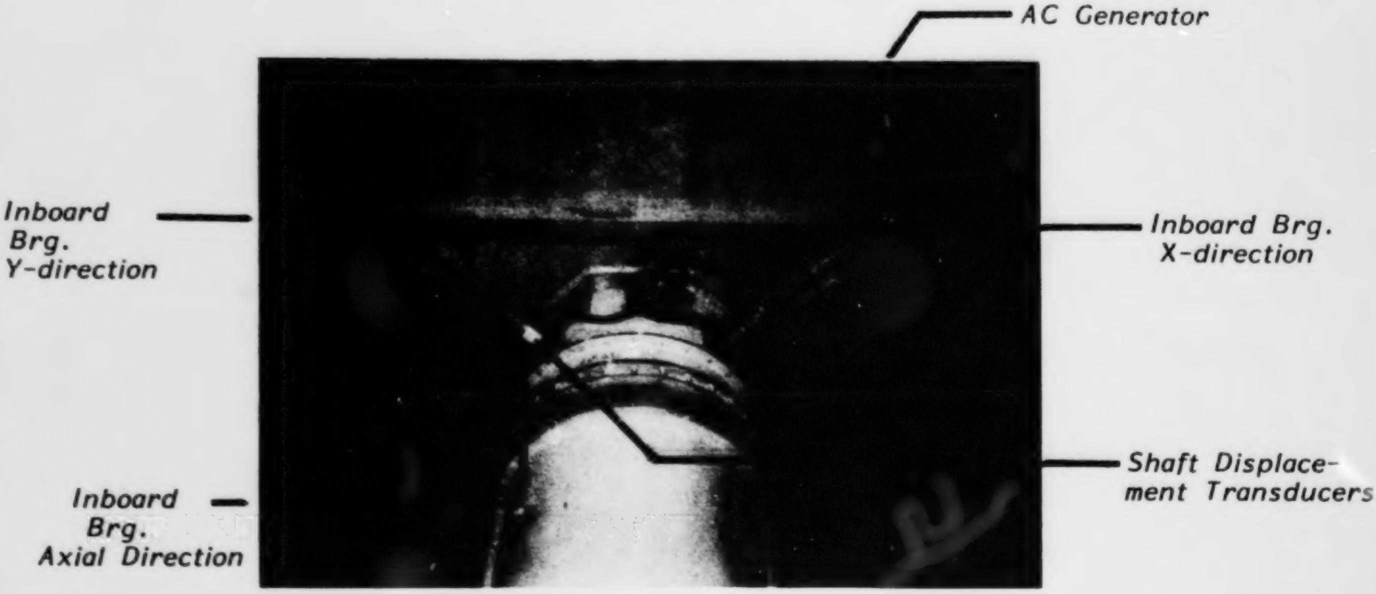


(d)

FIGURES 3(c) & (d)
LAYOUT OF STANDBY GENERATOR SYSTEM



(a) AC Generator Outboard Bearing



(b) AC Generator Inboard Bearing

FIGURE 4

LOCATION AND DIRECTION OF TRANSDUCERS ON AC GENERATOR BEARINGS

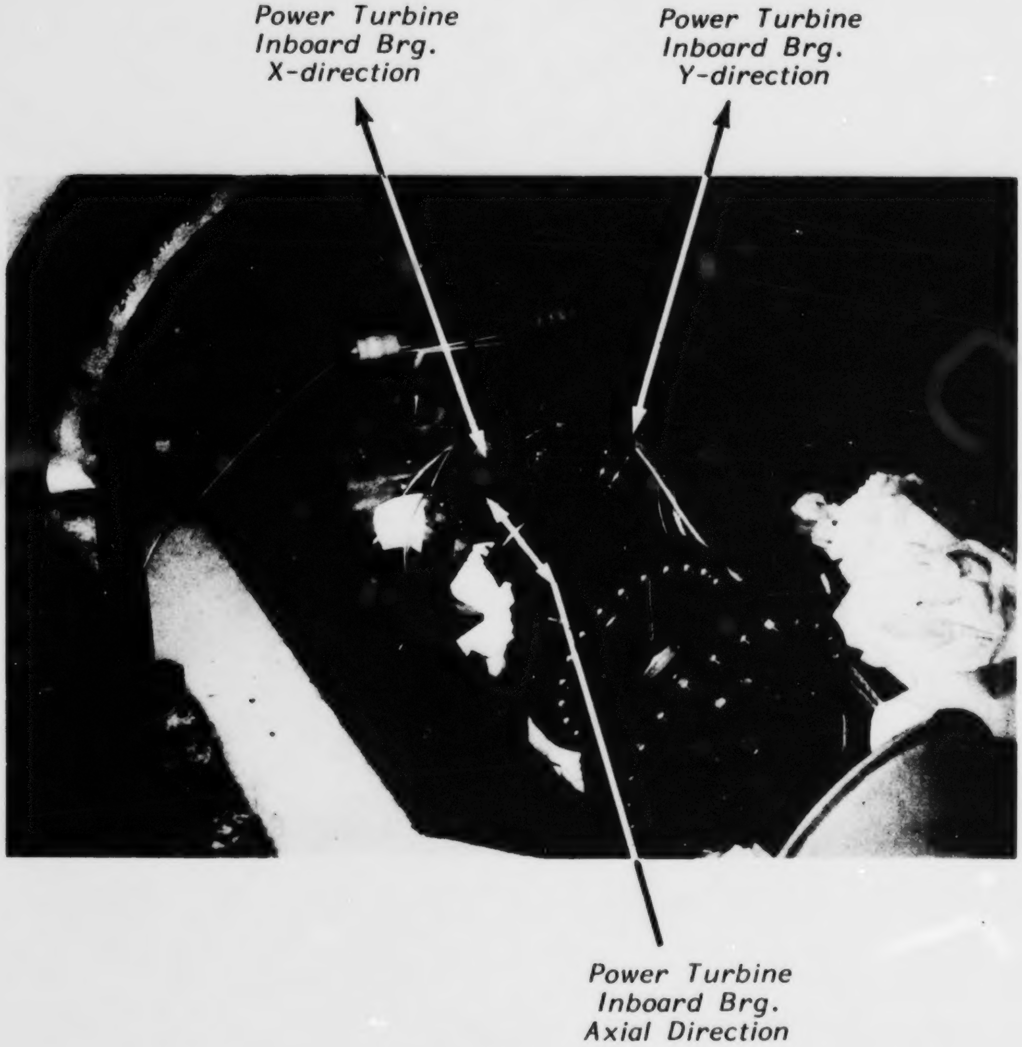


FIGURE 5

POWER TURBINE INBOARD BEARING MEASUREMENT LOCATIONS

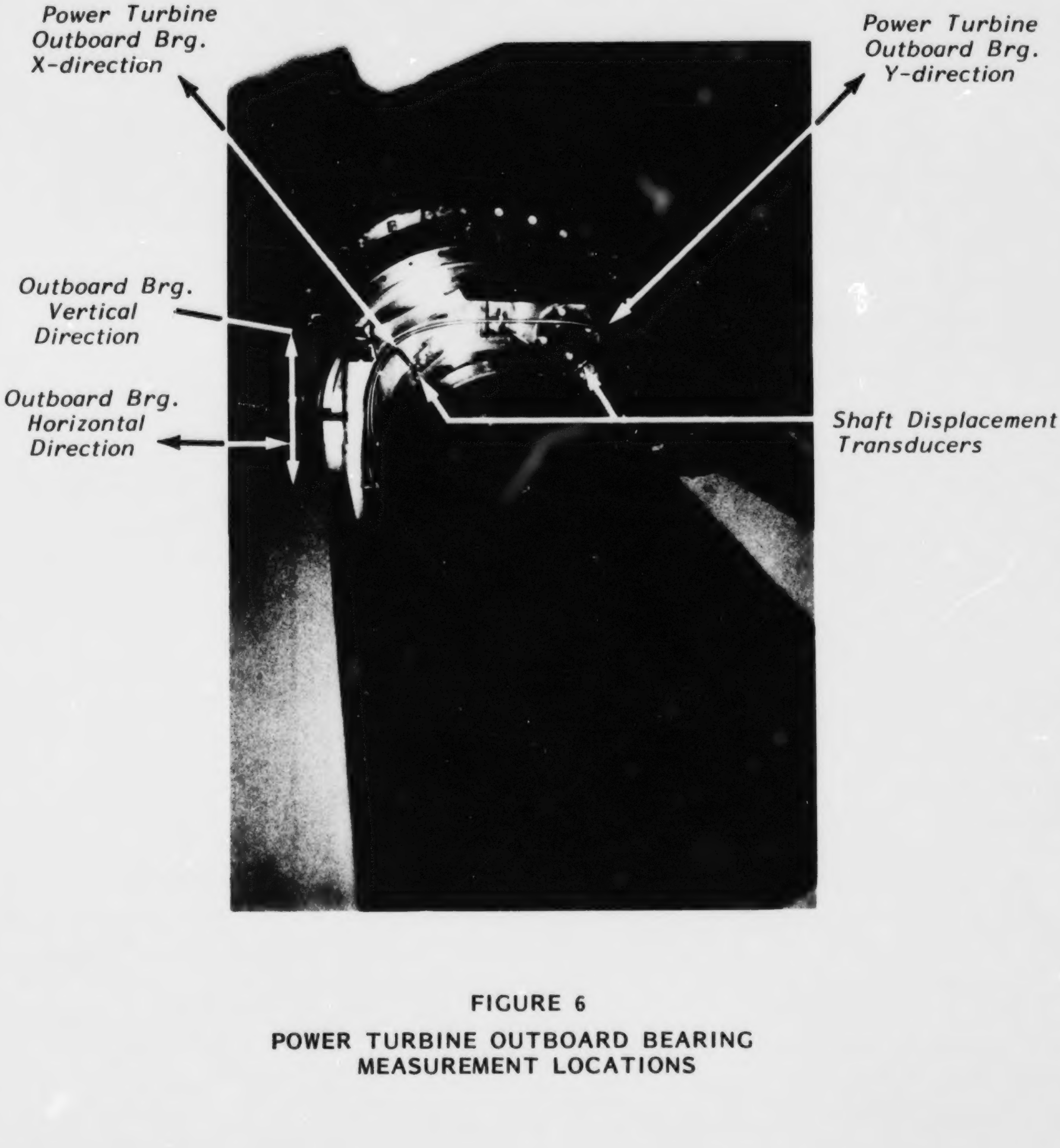


FIGURE 6

POWER TURBINE OUTBOARD BEARING MEASUREMENT LOCATIONS

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.41
2	180.0	3.00	0.24
3	60.0	1.00	0.18
4	240.0	4.00	0.07
5	480.0	8.00	0.04
6	600.0	10.00	0.03
7	19.5	0.33	0.02
8	94.9	1.58	0.02
9	300.0	5.00	0.02
10	540.0	9.00	0.02

SCALE: Linear DATE: 01-27-87

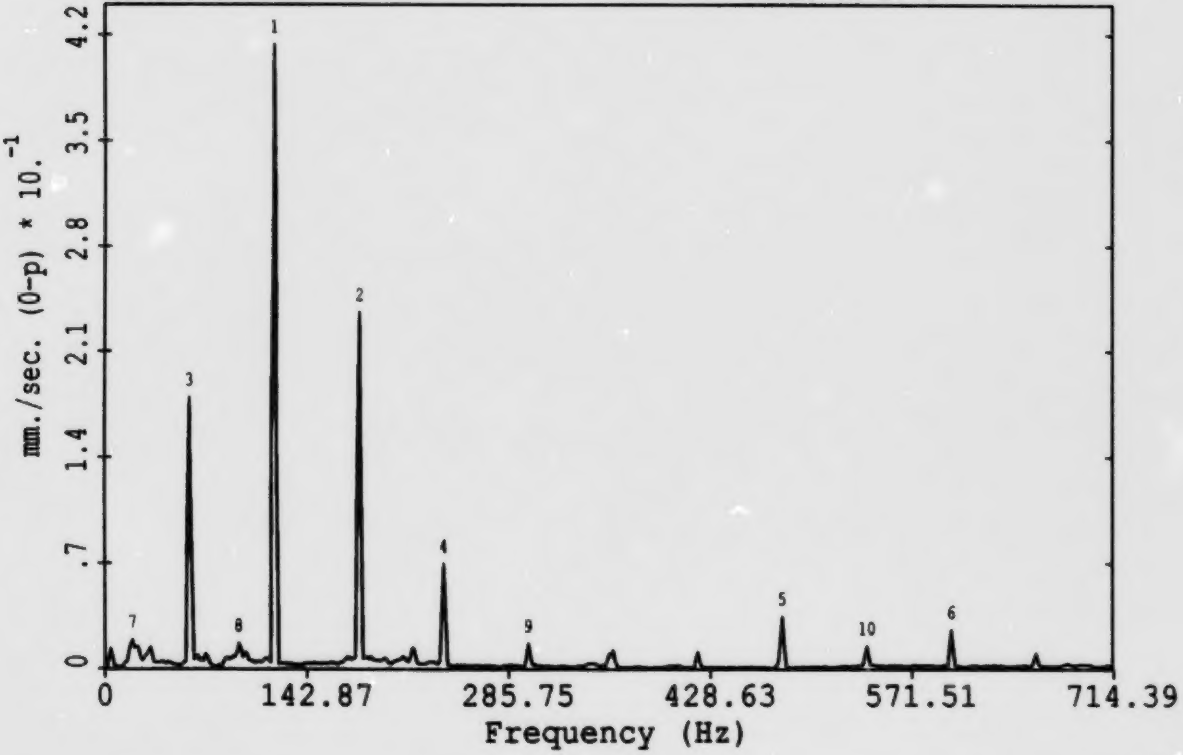


FIGURE 7

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.43
2	180.0	3.00	0.24
3	60.0	1.00	0.17
4	360.0	6.00	0.08
5	240.0	4.00	0.05
6	300.0	5.00	0.04
7	480.0	8.00	0.03
8	420.0	7.00	0.02
9	4.2	0.07	0.02
10	23.7	0.40	0.02

SCALE: Linear

DATE: 01-27-87

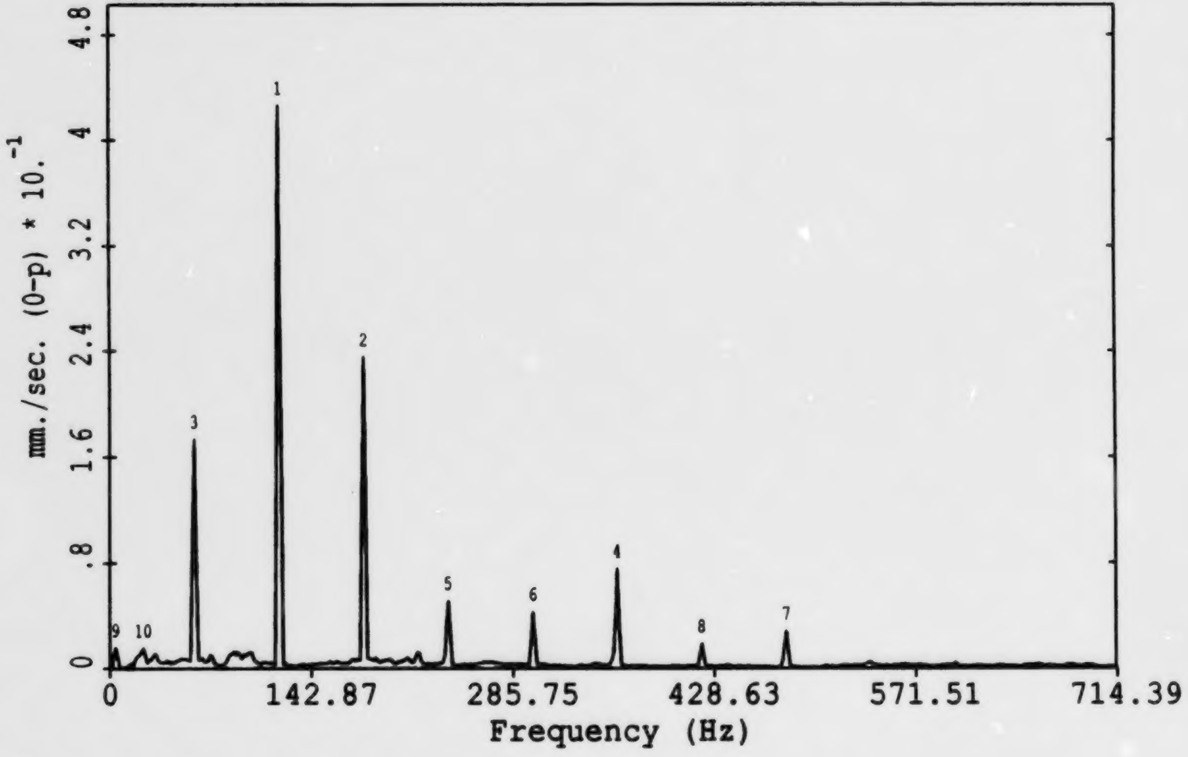


FIGURE 8

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.22
2	120.0	2.00	0.14
3	94.9	1.58	0.10
4	87.9	1.47	0.08
5	90.7	1.51	0.08
6	360.0	6.00	0.07
7	100.5	1.67	0.07
8	300.0	5.00	0.06
9	480.0	8.00	0.03
10	540.0	9.00	0.03

SCALE: Linear

DATE: 01-27-87

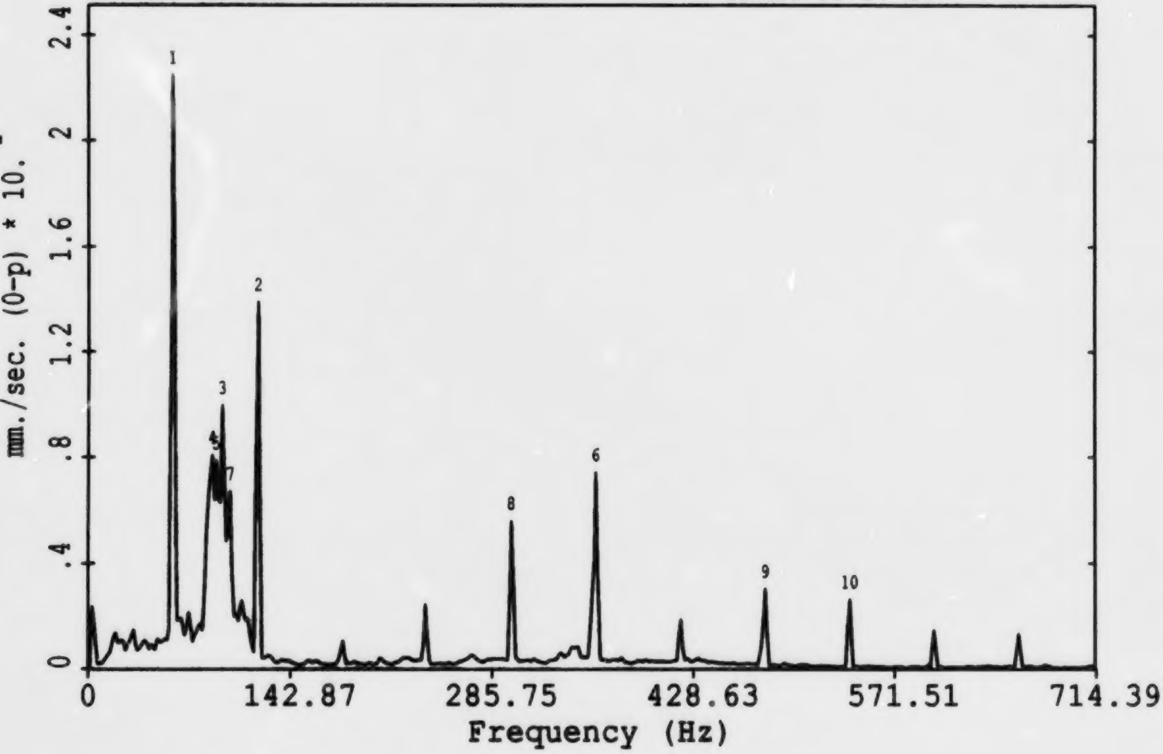


FIGURE 9

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.46
2	60.0	1.00	0.17
3	240.0	4.00	0.09
4	180.0	3.00	0.08
5	360.0	6.00	0.04
6	19.5	0.33	0.03
7	420.0	7.00	0.03
8	300.0	5.00	0.02
9	71.2	1.19	0.02
10	540.0	9.00	0.02

SCALE: Linear DATE: 01-27-87

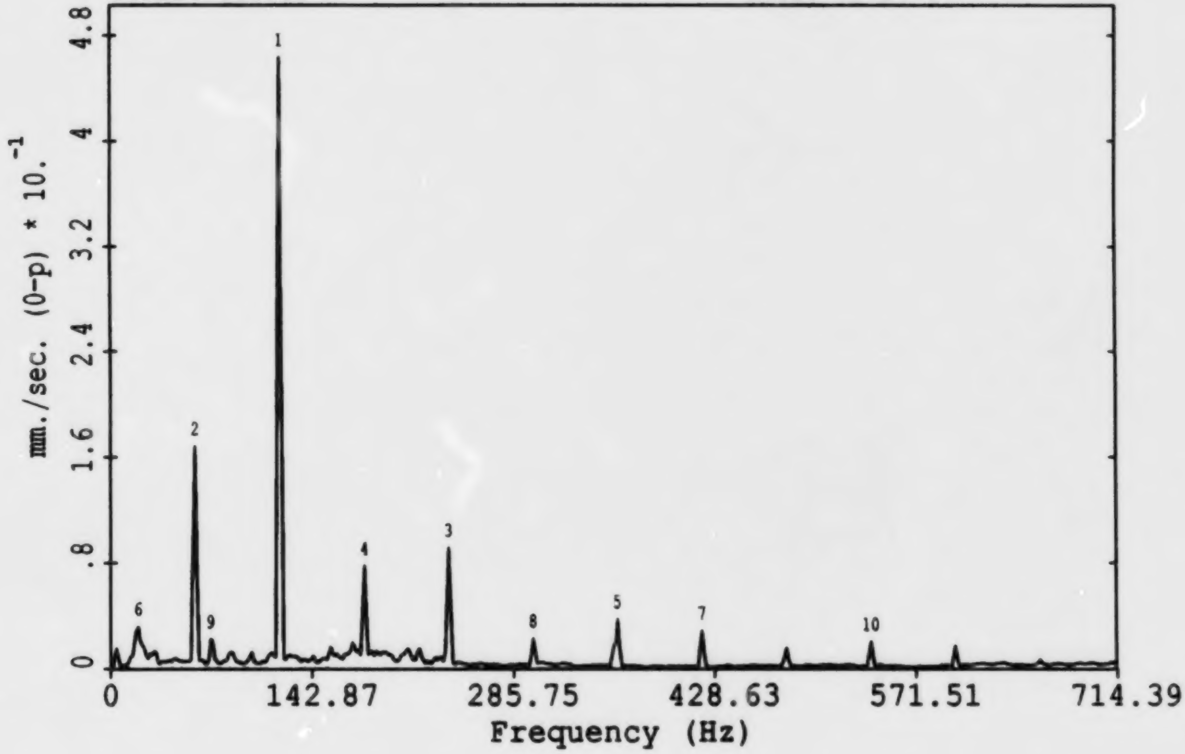


FIGURE 10

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.32
2	60.0	1.00	0.23
3	180.0	3.00	0.15
4	240.0	4.00	0.07
5	300.0	5.00	0.03
6	420.0	7.00	0.03
7	210.7	3.51	0.03
8	219.1	3.65	0.03
9	480.0	8.00	0.03
10	171.6	2.86	0.02

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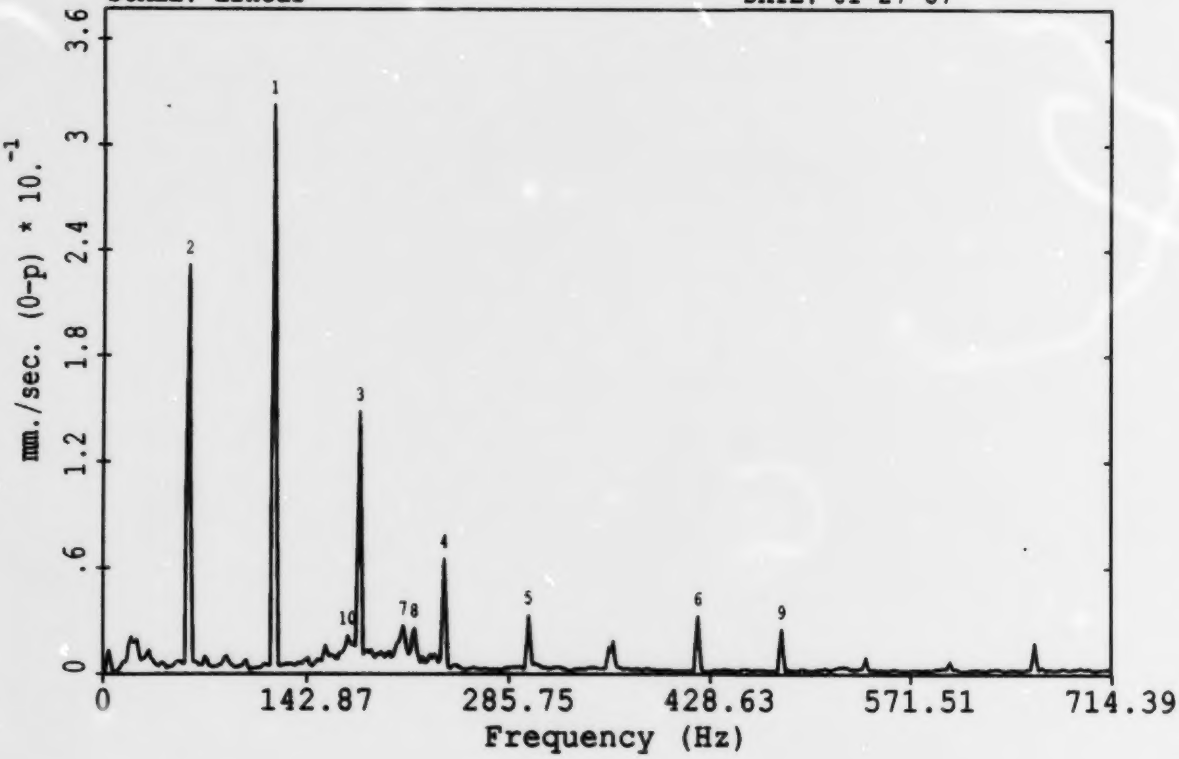


FIGURE 11

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.18
2	60.0	1.00	0.14
3	86.5	1.44	0.08
4	71.2	1.19	0.05
5	100.5	1.67	0.04
6	357.2	5.95	0.04
7	240.0	4.00	0.03
8	480.0	8.00	0.02
9	360.0	6.00	0.02
10	180.0	3.00	0.02

SCALE: Linear   DATE: 01-27-87

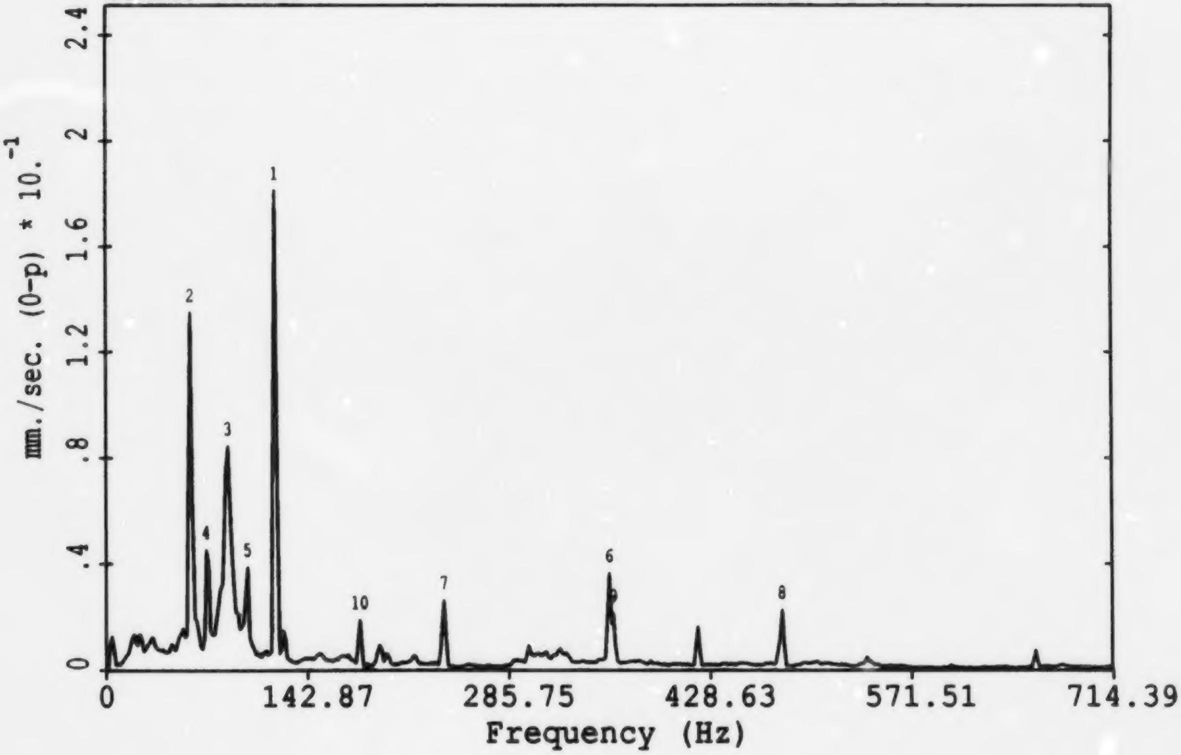


FIGURE 12

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.37
2	180.0	3.00	0.22
3	60.0	1.00	0.17
4	480.0	8.00	0.03
5	240.0	4.00	0.03
6	600.0	10.00	0.03
7	300.0	5.00	0.03
8	19.5	0.33	0.02
9	540.0	9.00	0.02
10	110.2	1.84	0.02

SCALE: Linear

DATE: 01-27-87

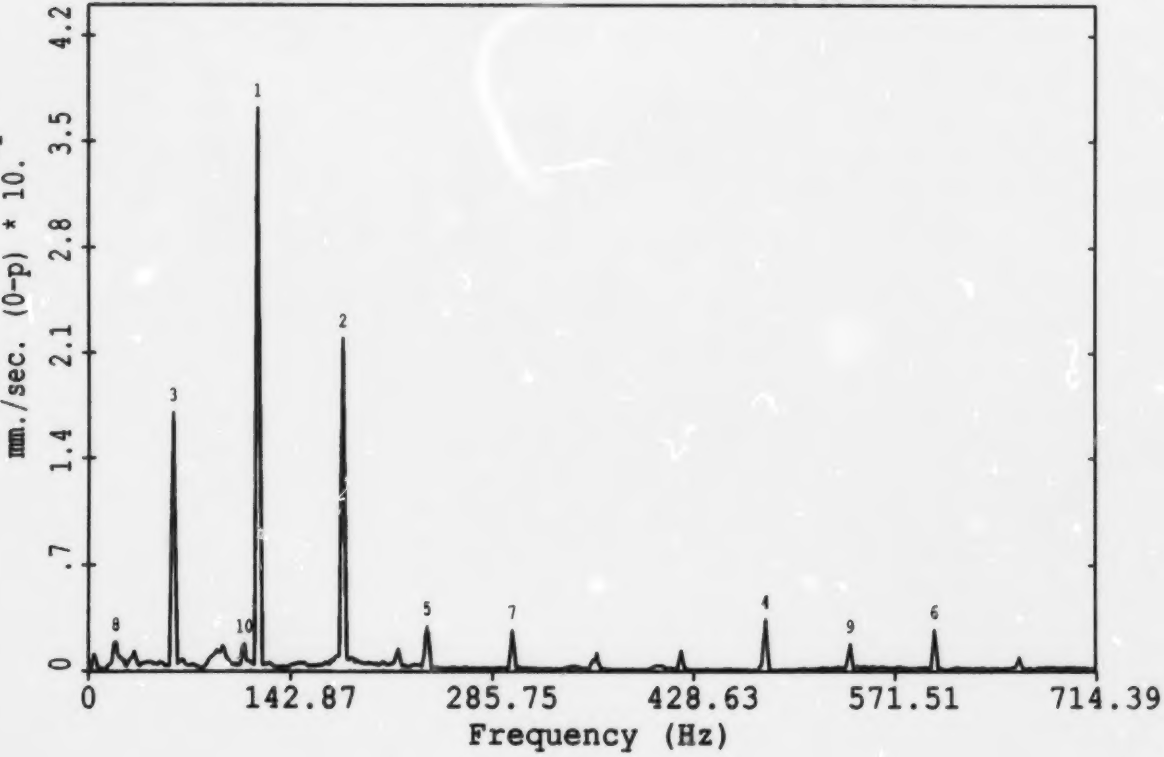


FIGURE 13

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.41
2	180.0	3.00	0.22
3	60.0	1.00	0.20
4	360.0	6.00	0.10
5	300.0	5.00	0.03
6	480.0	8.00	0.02
7	240.0	4.00	0.02
8	420.0	7.00	0.02
9	20.9	0.35	0.02
10	87.9	1.47	0.02

SCALE: Linear

DATE: 01-27-87

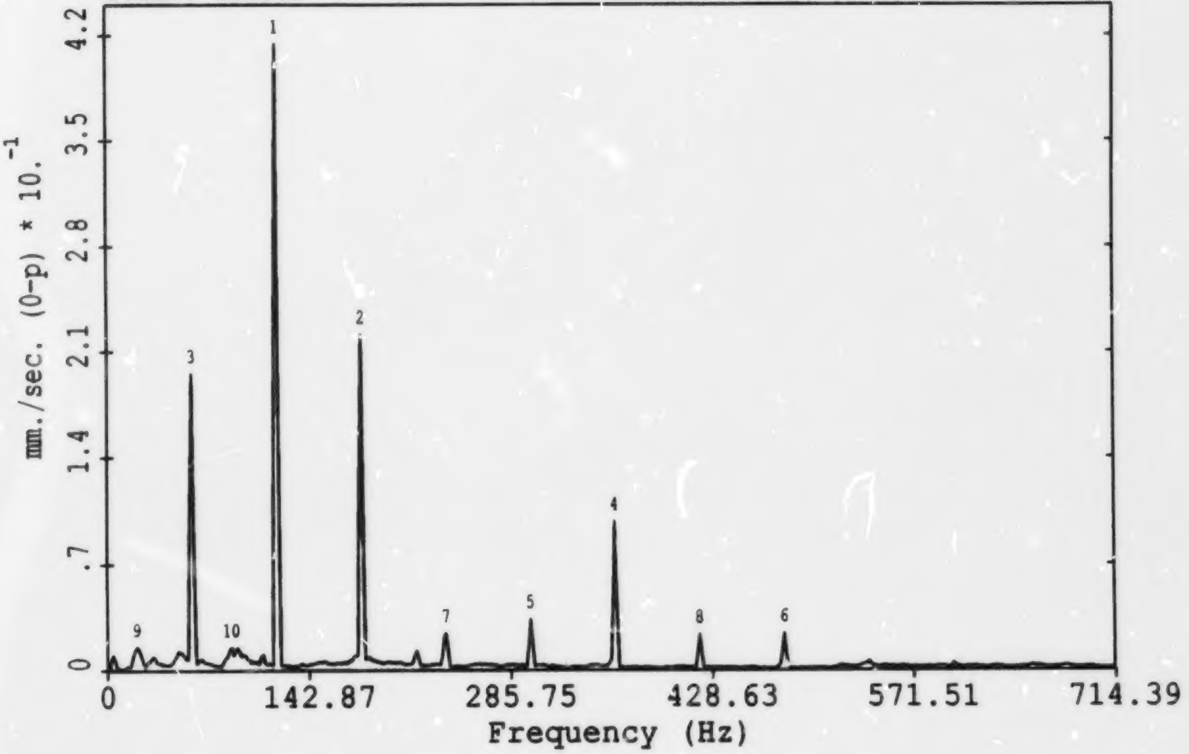


FIGURE 14

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.22
2	120.0	2.00	0.16
3	87.9	1.47	0.10
4	360.0	6.00	0.10
5	92.1	1.53	0.09
6	94.9	1.58	0.09
7	110.2	1.84	0.05
8	240.0	4.00	0.05
9	300.0	5.00	0.05
10	420.0	7.00	0.03

SCALE: Linear

DATE: 01-27-87

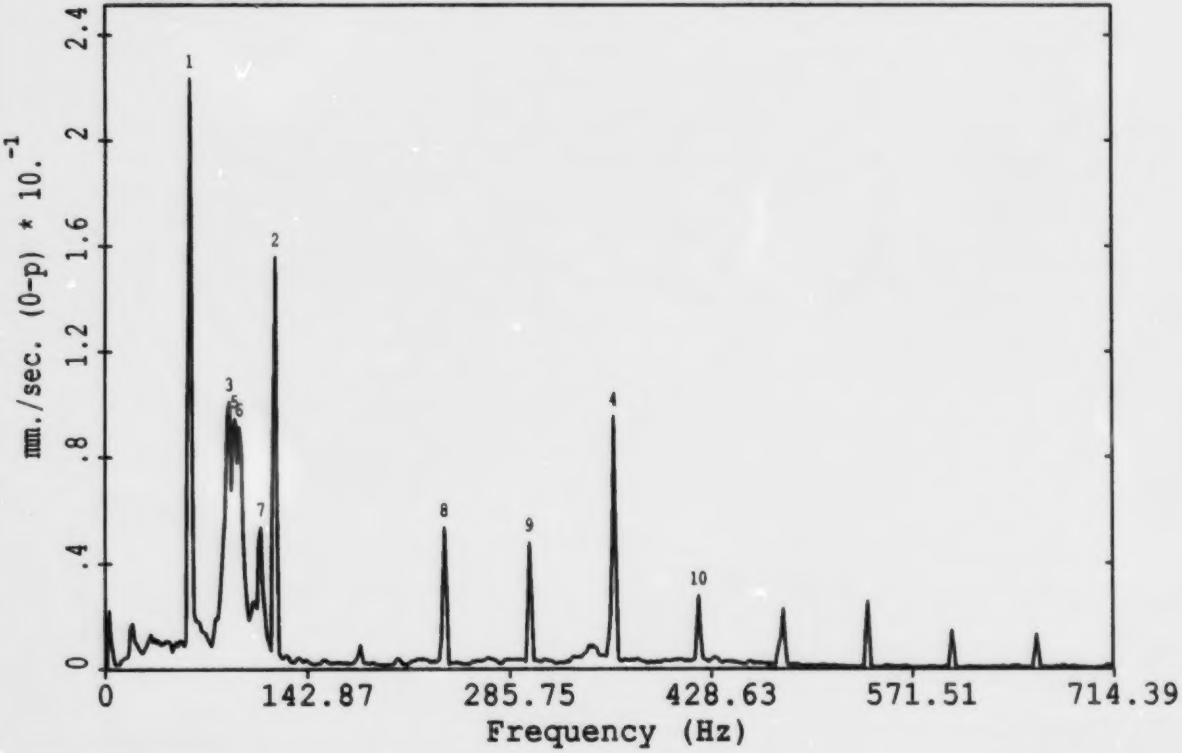


FIGURE 15

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.53
2	60.0	1.00	0.17
3	240.0	4.00	0.08
4	360.0	6.00	0.05
5	180.0	3.00	0.04
6	19.5	0.33	0.04
7	420.0	7.00	0.03
8	110.2	1.84	0.03
9	300.0	5.00	0.02
10	167.4	2.79	0.02

SCALE: Linear

DATE: 01-27-87

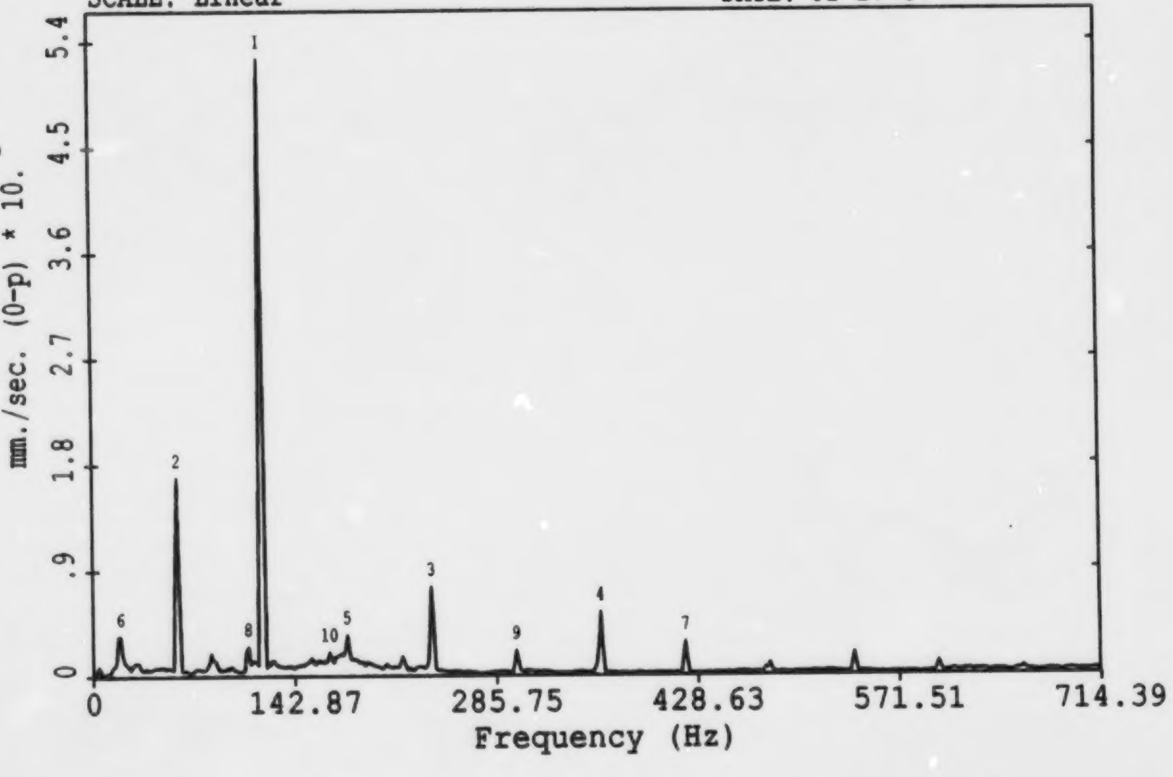


FIGURE 16

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.33
2	60.0	1.00	0.23
3	180.0	3.00	0.09
4	240.0	4.00	0.09
5	300.0	5.00	0.04
6	420.0	7.00	0.03
7	19.5	0.33	0.03
8	219.1	3.65	0.03
9	167.4	2.79	0.02
10	175.8	2.93	0.02

SCALE: Linear

DATE: 01-27-87

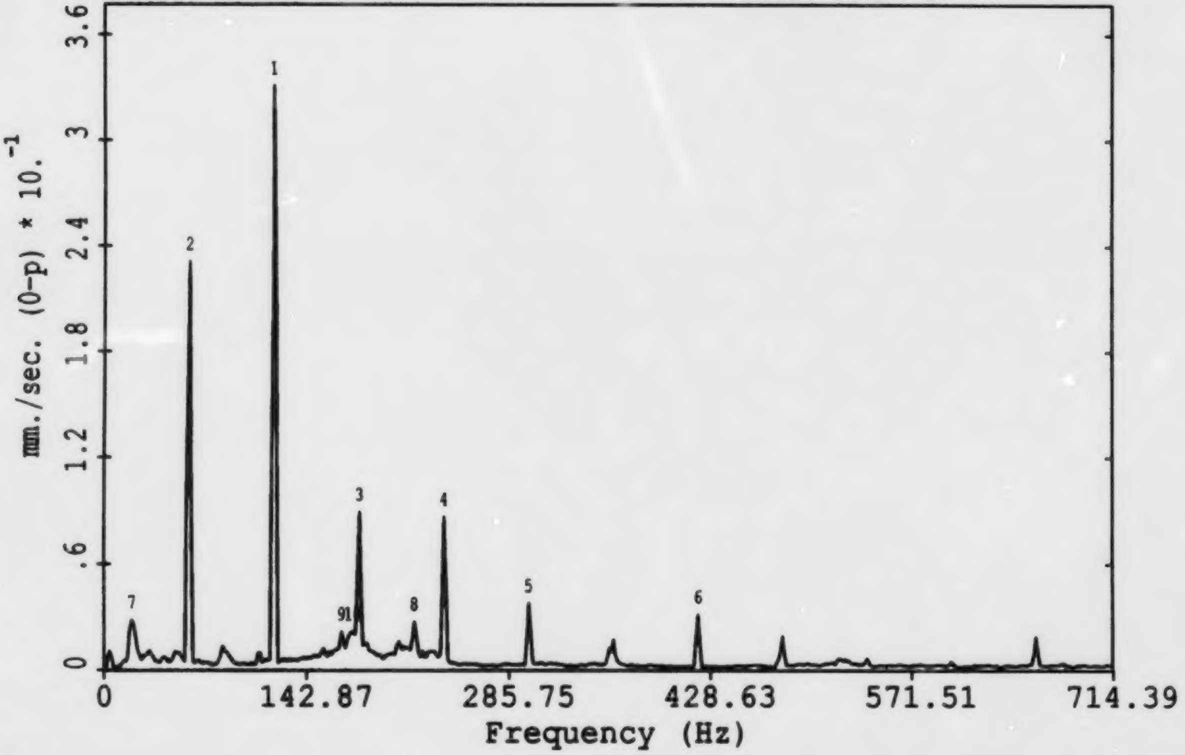


FIGURE 17

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	83.7	1.40	0.12
2	120.0	2.00	0.12
3	60.0	1.00	0.11
4	86.5	1.44	0.10
5	110.2	1.84	0.04
6	480.0	8.00	0.03
7	238.6	3.98	0.02
8	357.2	5.95	0.02
9	97.7	1.63	0.02
10	19.5	0.33	0.02

SCALE: Linear

DATE: 01-27-87

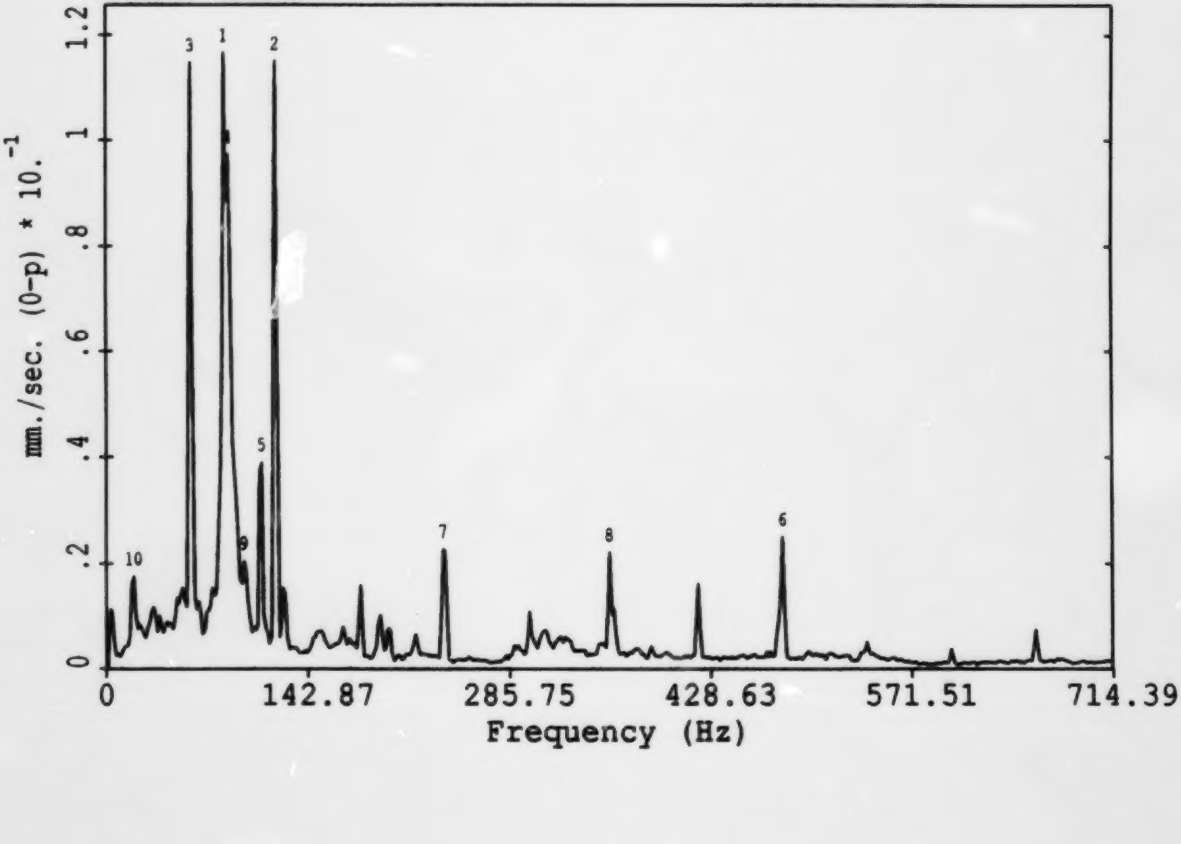


FIGURE 18

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.29
2	180.0	3.00	0.21
3	60.0	1.00	0.14
4	600.0	10.00	0.03
5	19.5	0.33	0.03
6	480.0	8.00	0.03
7	238.6	3.98	0.03
8	300.0	5.00	0.03
9	115.8	1.93	0.03
10	540.0	9.00	0.02

SCALE: Linear

DATE: 01-27-87

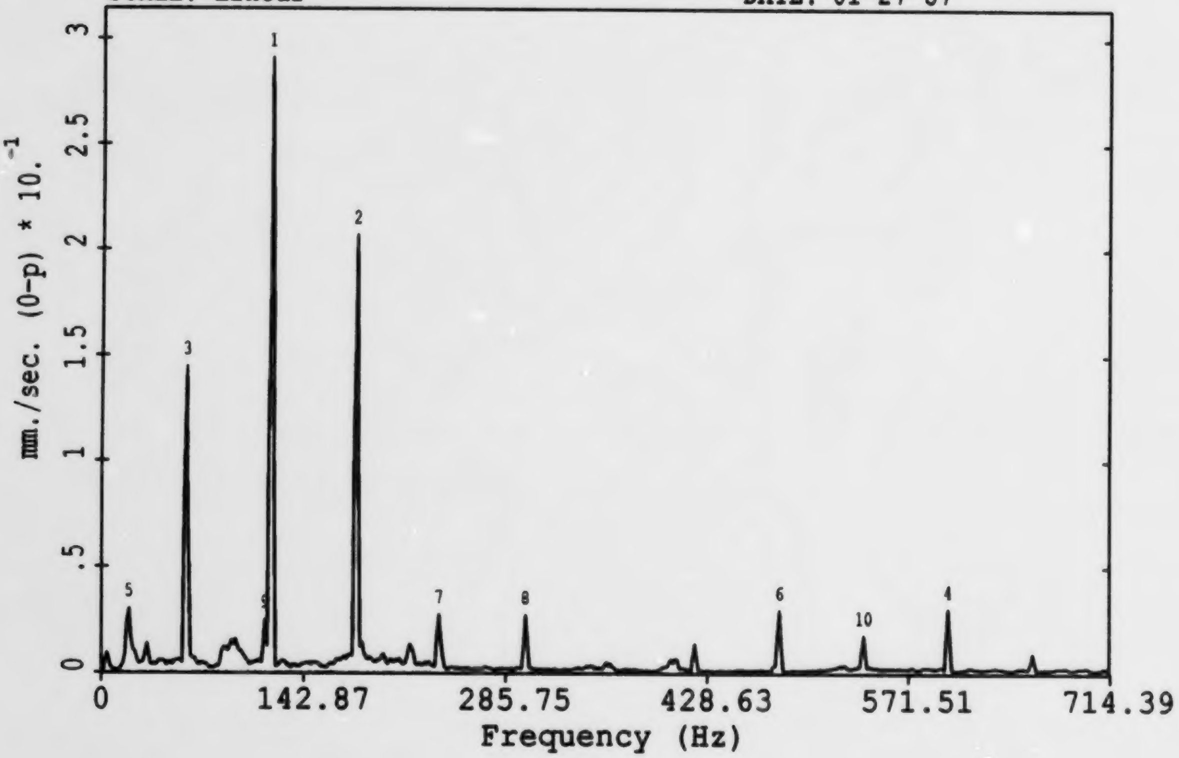


FIGURE 19

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 15 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.34
2	180.0	3.00	0.21
3	60.0	1.00	0.18
4	240.0	4.00	0.09
5	360.0	6.00	0.09
6	300.0	5.00	0.03
7	480.0	8.00	0.02
8	420.0	7.00	0.02
9	92.1	1.53	0.02
10	54.4	0.91	0.02

SCALE: Linear

DATE: 01-27-87

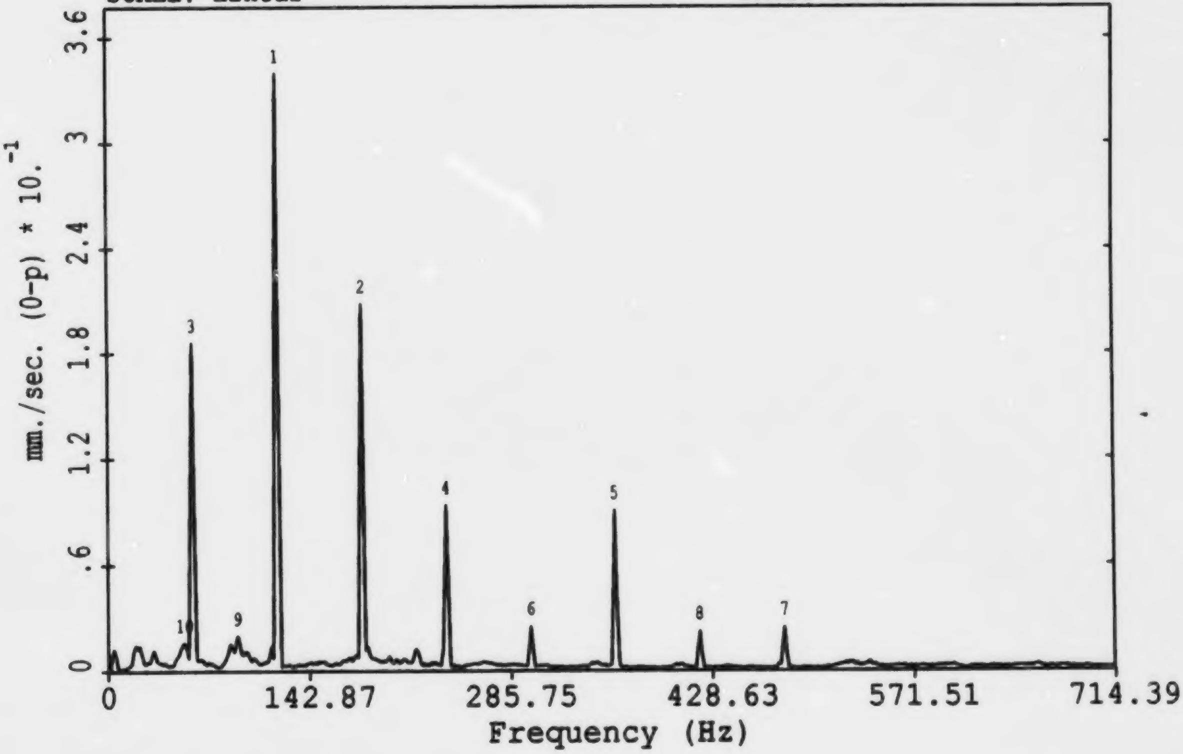


FIGURE 20

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.22
2	120.0	2.00	0.13
3	240.0	4.00	0.12
4	86.5	1.44	0.11
5	92.1	1.53	0.09
6	360.0	6.00	0.08
7	300.0	5.00	0.04
8	104.6	1.74	0.03
9	115.8	1.93	0.03
10	110.2	1.84	0.03

SCALE: Linear

DATE: 01-27-87

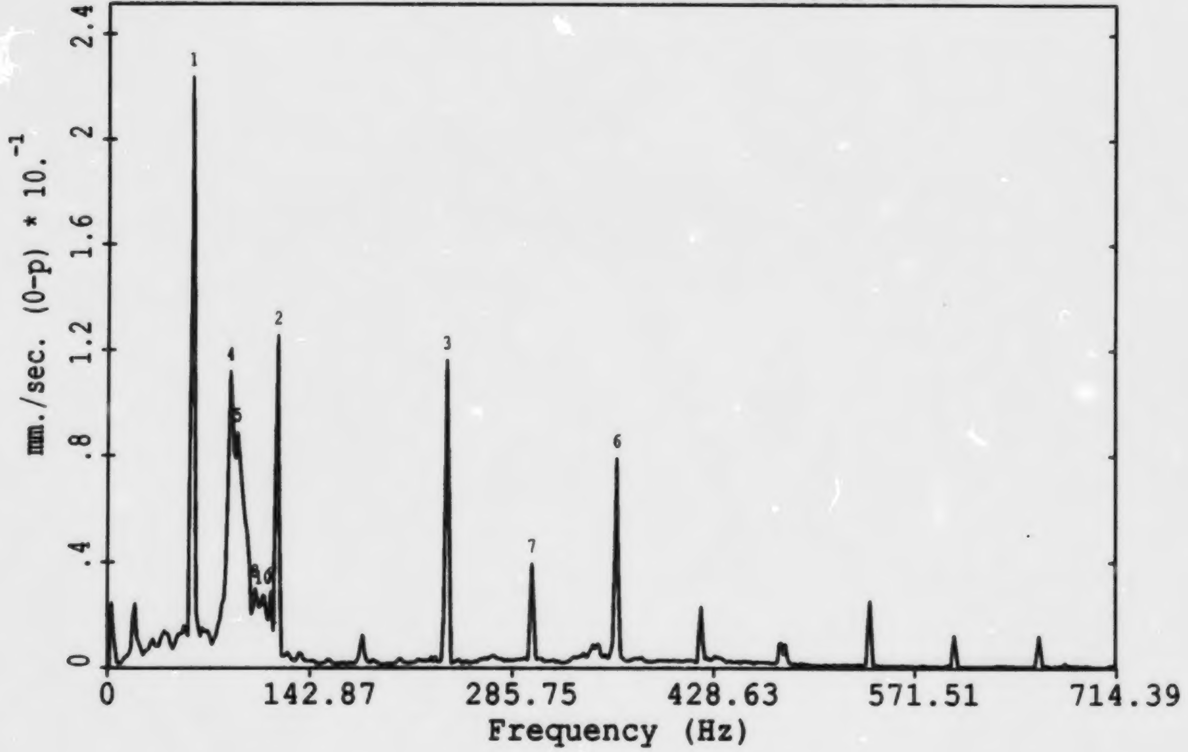


FIGURE 21

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.59
2	60.0	1.00	0.15
3	240.0	4.00	0.15
4	360.0	6.00	0.06
5	115.8	1.93	0.05
6	19.5	0.33	0.05
7	180.0	3.00	0.05
8	184.2	3.07	0.03
9	420.0	7.00	0.03
10	300.0	5.00	0.02

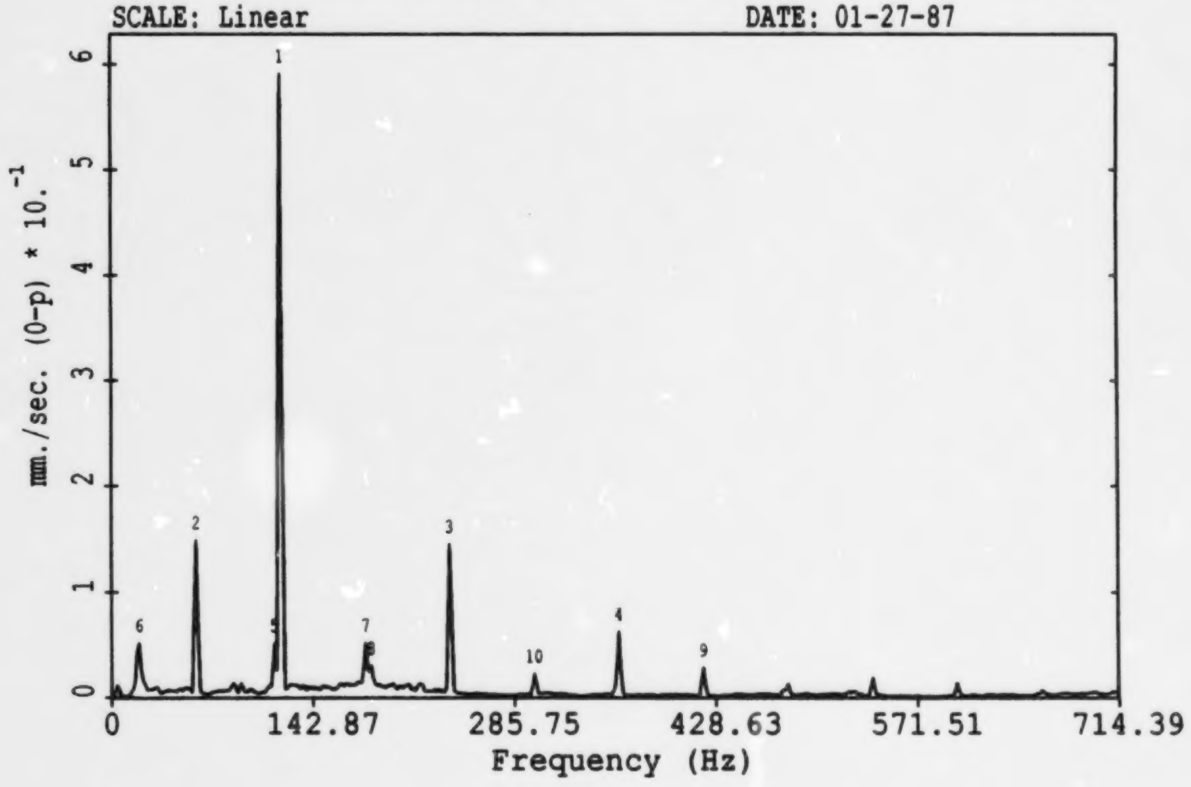


FIGURE 22

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 15 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.46
2	60.0	1.00	0.23
3	240.0	4.00	0.18
4	180.0	3.00	0.08
5	300.0	5.00	0.05
6	19.5	0.33	0.03
7	420.0	7.00	0.03
8	219.1	3.65	0.03
9	184.2	3.07	0.03
10	480.0	8.00	0.02

SCALE: Linear

DATE: 01-27-87

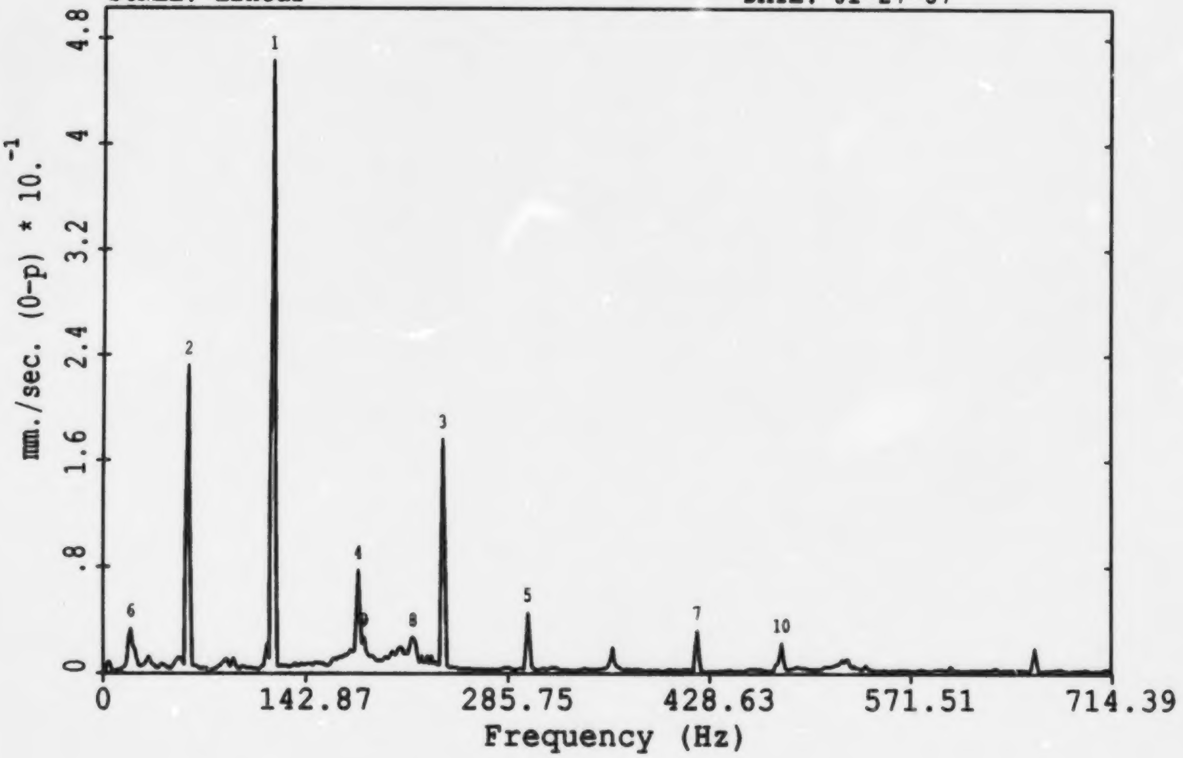


FIGURE 23

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	86.5	1.44	0.11
2	60.0	1.00	0.10
3	240.0	4.00	0.07
4	120.0	2.00	0.06
5	92.1	1.53	0.03
6	360.0	6.00	0.03
7	19.5	0.33	0.02
8	54.4	0.91	0.02
9	180.0	3.00	0.02
10	420.0	7.00	0.02

SCALE: Linear DATE: 01-27-87

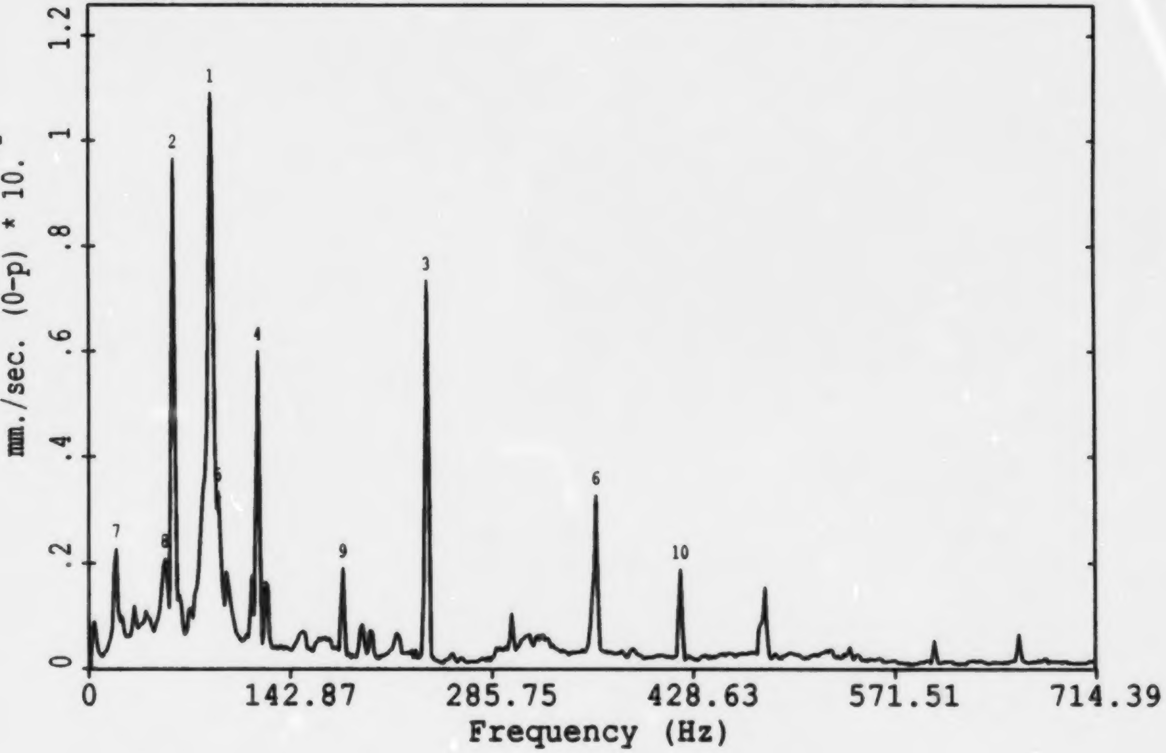


FIGURE 24

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.21
2	180.0	3.00	0.21
3	60.0	1.00	0.11
4	240.0	4.00	0.07
5	300.0	5.00	0.03
6	480.0	8.00	0.03
7	600.0	10.00	0.03
8	200.9	3.35	0.02
9	219.1	3.65	0.02
10	19.5	0.33	0.02

SCALE: Linear

DATE: 01-27-87

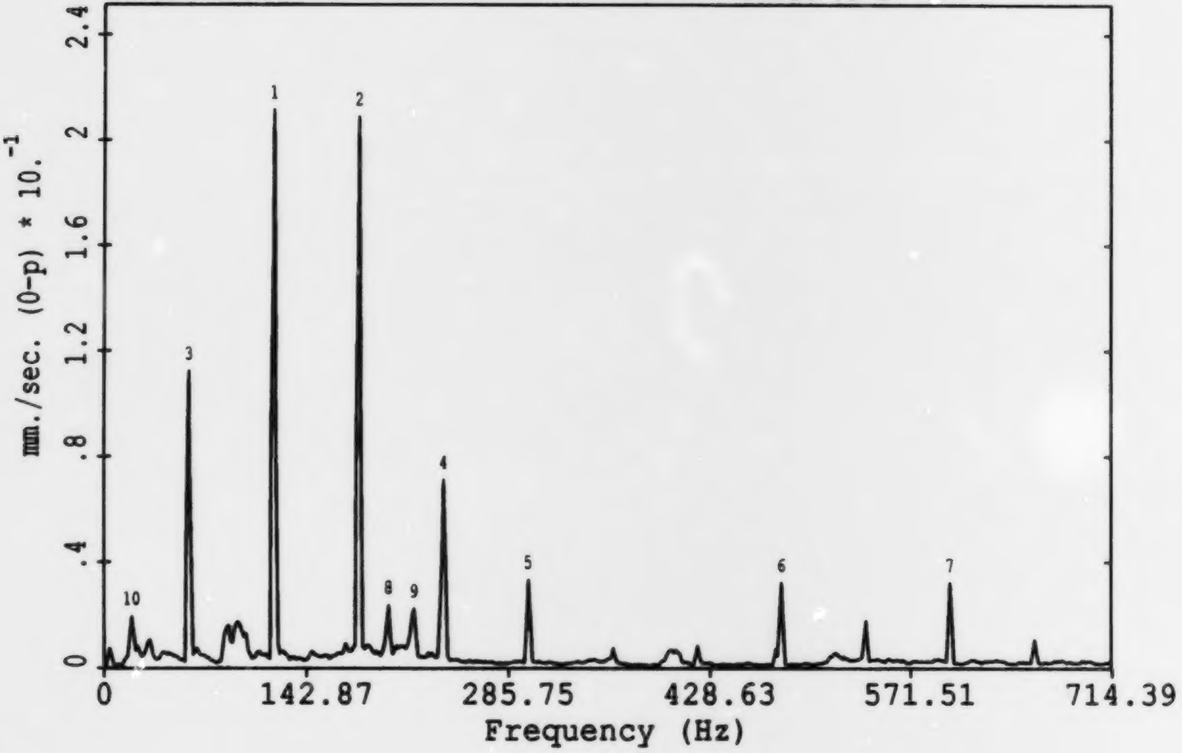


FIGURE 25

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.29
2	180.0	3.00	0.21
3	60.0	1.00	0.16
4	240.0	4.00	0.16
5	360.0	6.00	0.10
6	480.0	8.00	0.02
7	200.9	3.35	0.02
8	219.1	3.65	0.02
9	86.5	1.44	0.02
10	20.9	0.35	0.02

SCALE: Linear

DATE: 01-27-87

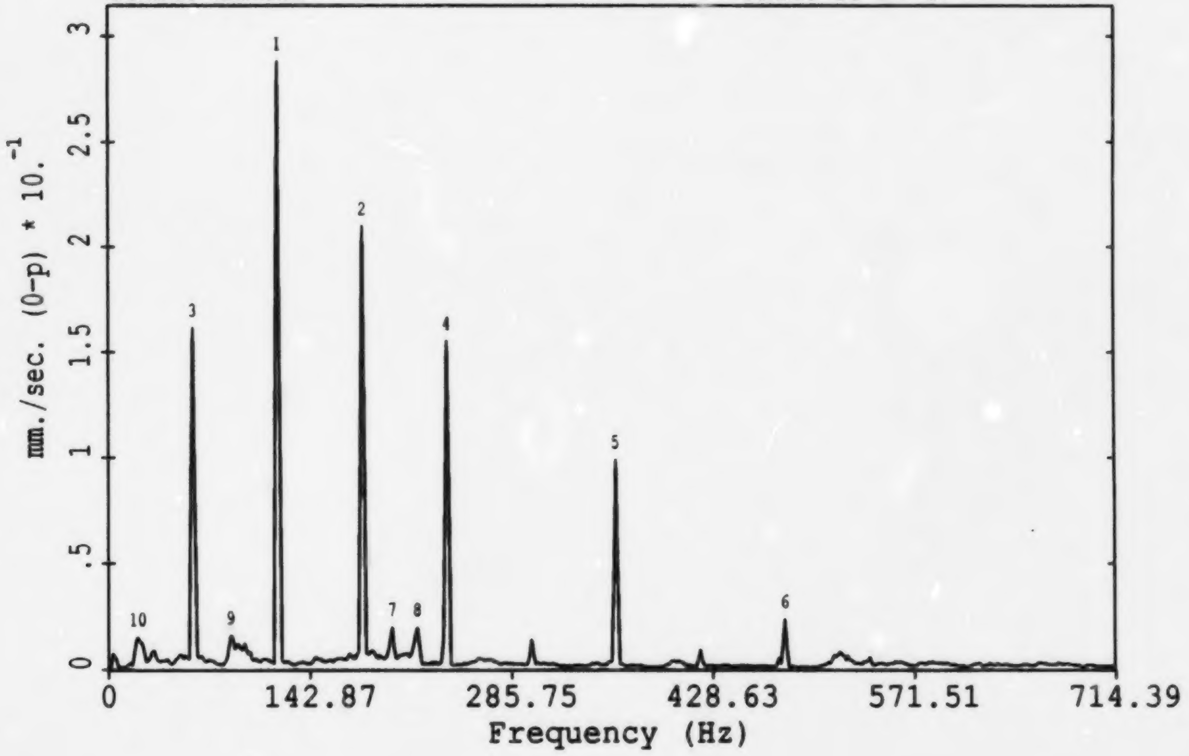


FIGURE 26

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.22
2	120.0	2.00	0.16
3	240.0	4.00	0.15
4	87.9	1.47	0.11
5	360.0	6.00	0.10
6	96.3	1.60	0.08
7	92.1	1.53	0.07
8	300.0	5.00	0.05
9	110.2	1.84	0.03
10	2.8	0.05	0.03

SCALE: Linear

DATE: 01-27-87

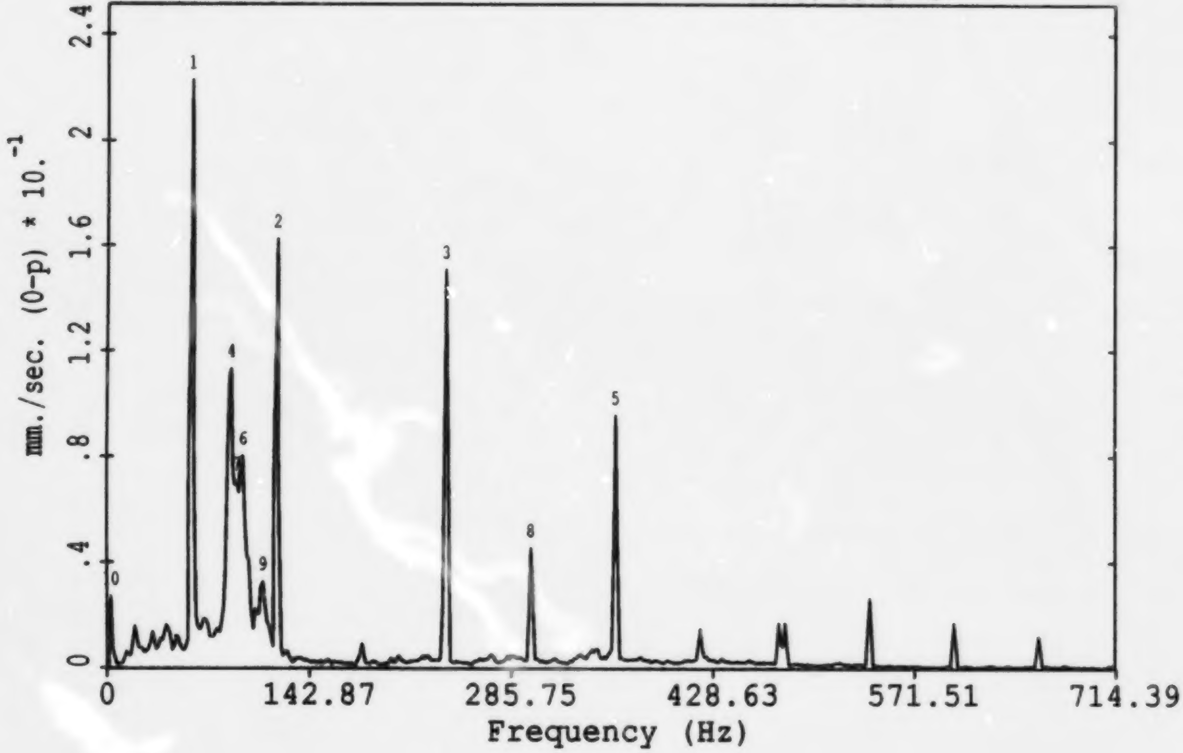


FIGURE 27

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.79
2	240.0	4.00	0.31
3	60.0	1.00	0.13
4	360.0	6.00	0.08
5	180.0	3.00	0.05
6	200.9	3.35	0.03
7	19.5	0.33	0.03
8	420.0	7.00	0.03

SCALE: Linear

DATE: 01-27-87

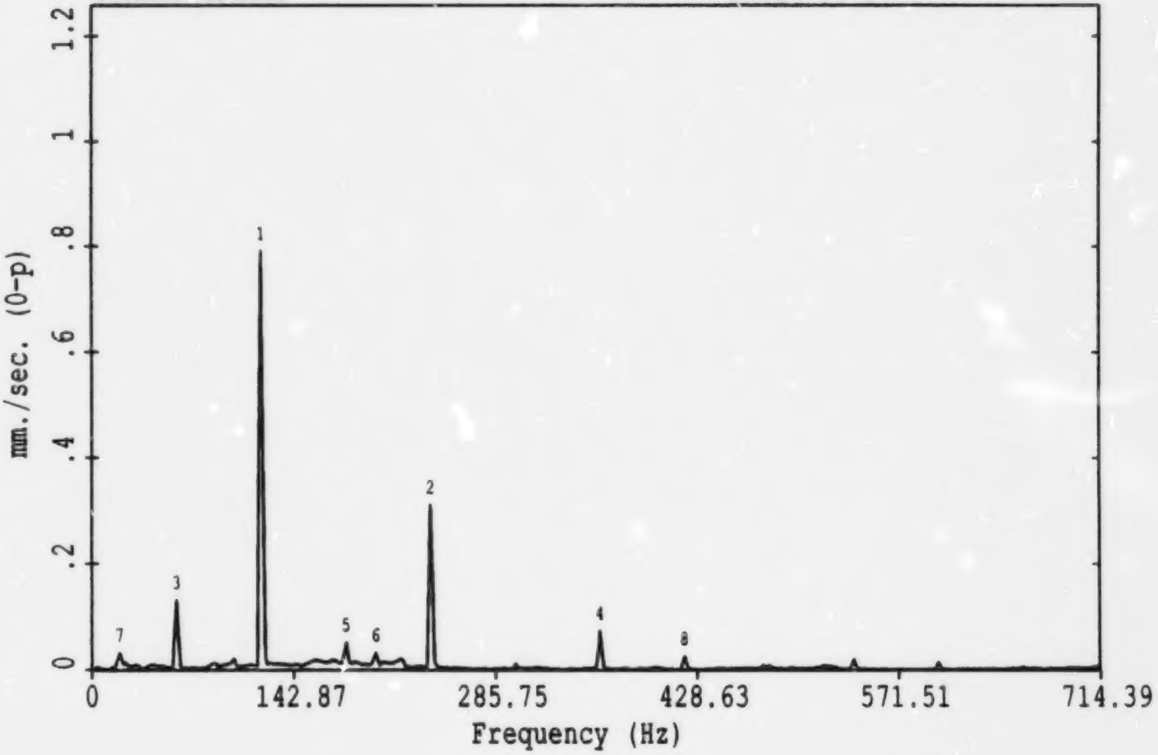


FIGURE 28

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.52
2	240.0	4.00	0.33
3	60.0	1.00	0.23
4	180.0	3.00	0.07
5	300.0	5.00	0.04
6	219.1	3.65	0.04
7	420.0	7.00	0.04
8	360.0	6.00	0.03
9	19.5	0.33	0.03
10	480.0	8.00	0.03

SCALE: Linear

DATE: 01-27-87

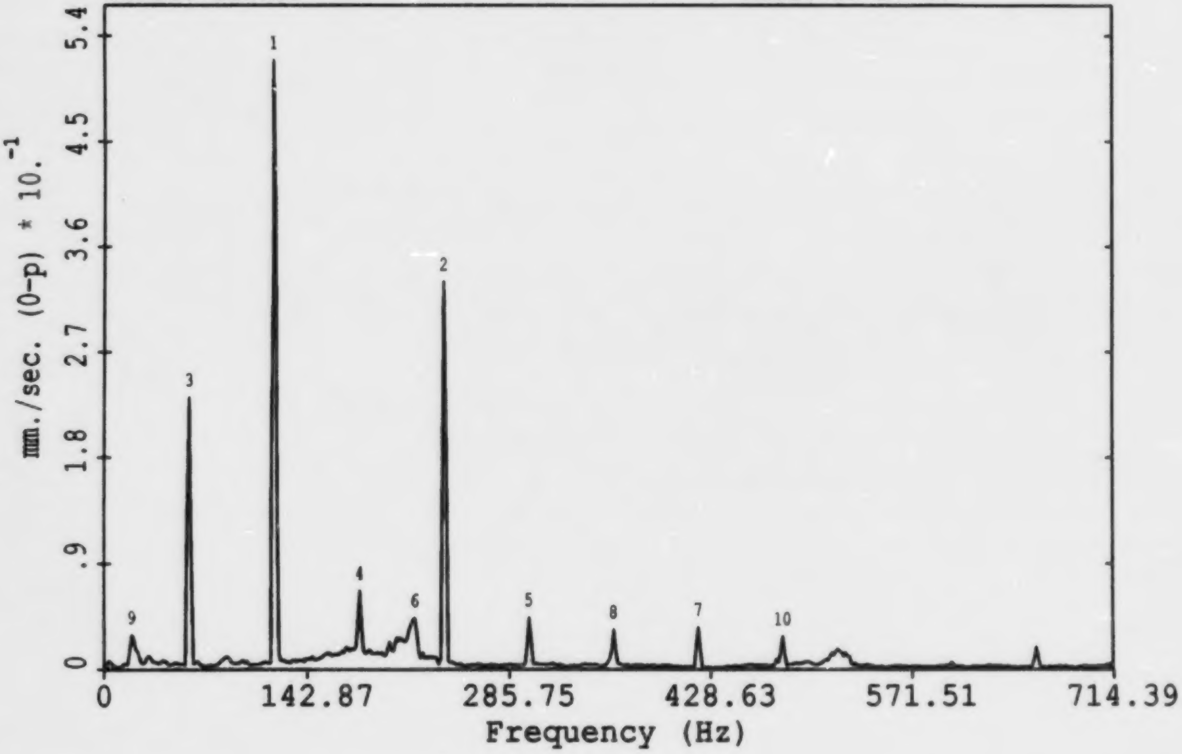


FIGURE 29

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	240.0	4.00	0.17
2	86.5	1.44	0.10
3	60.0	1.00	0.08
4	120.0	2.00	0.07
5	360.0	6.00	0.05
6	200.9	3.35	0.03
7	100.5	1.67	0.03
8	97.7	1.63	0.02
9	480.0	8.00	0.02
10	420.0	7.00	0.02

SCALE: Linear

DATE: 01-27-87

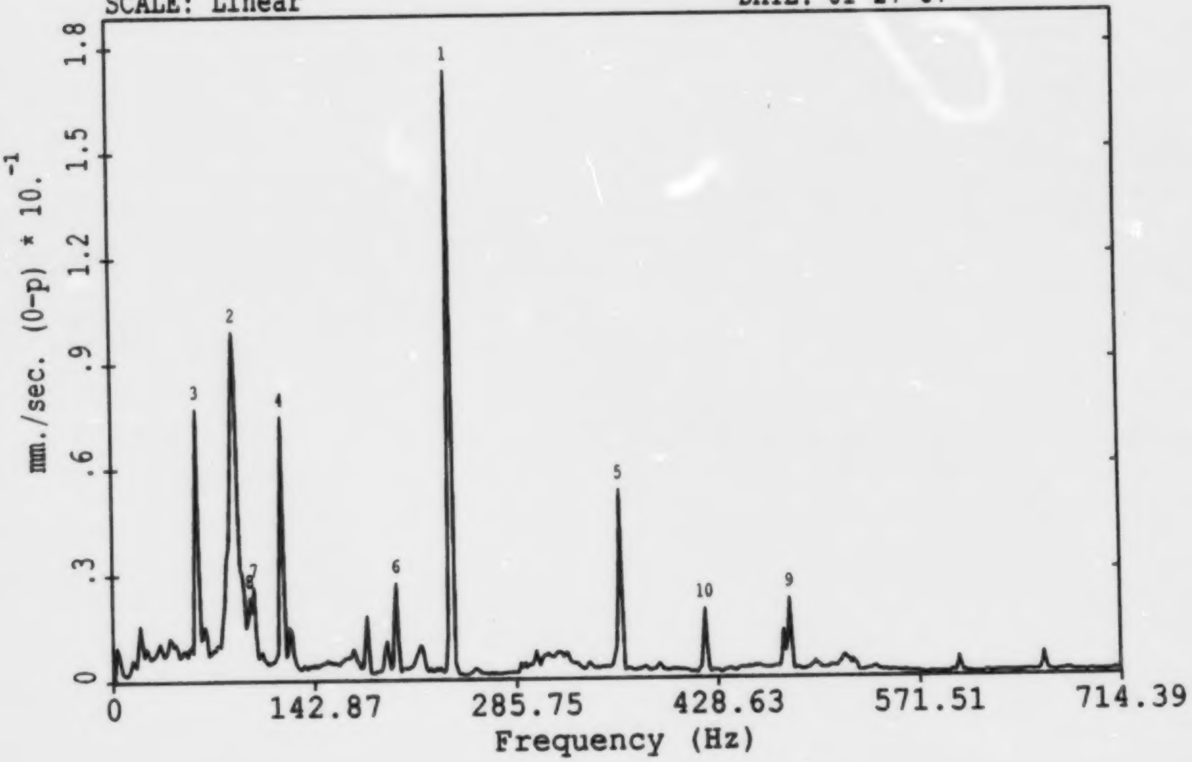


FIGURE 30

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.22
2	180.0	3.00	0.20
3	60.0	1.00	0.12
4	240.0	4.00	0.07
5	480.0	8.00	0.03
6	300.0	5.00	0.03
7	600.0	10.00	0.03
8	217.7	3.63	0.03
9	96.3	1.60	0.02
10	87.9	1.47	0.02

SCALE: Linear

DATE: 01-27-87

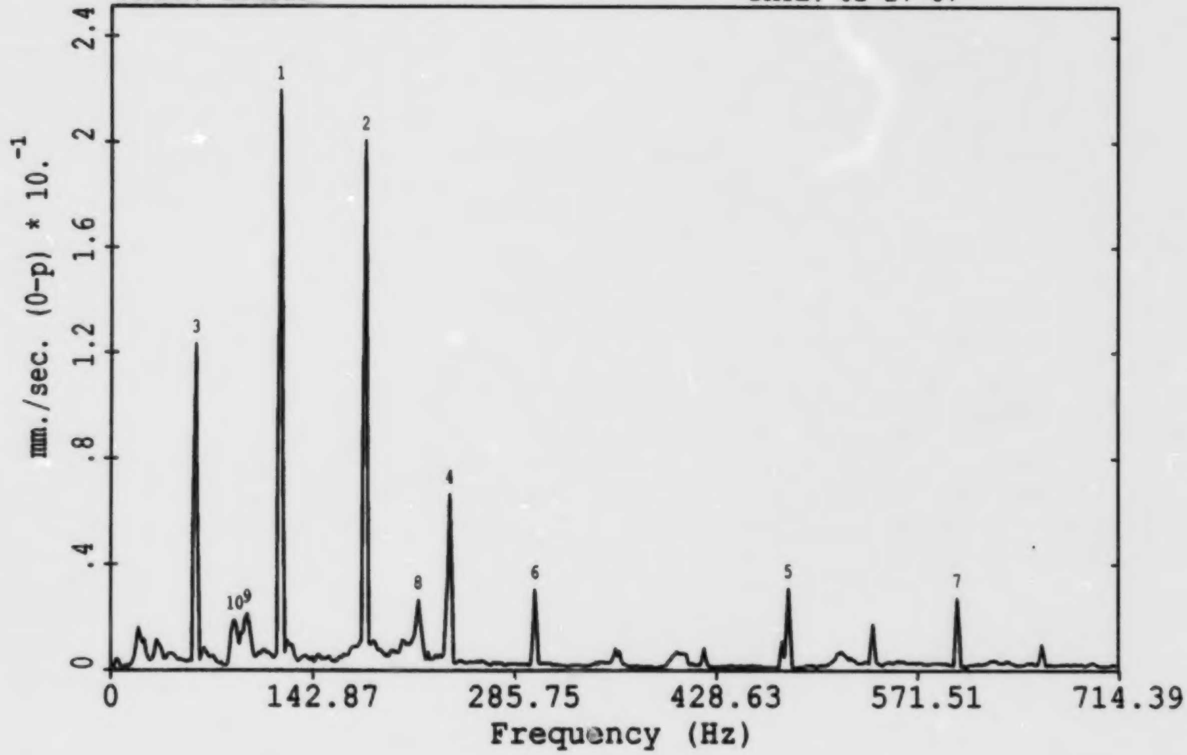


FIGURE 31

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.27
2	180.0	3.00	0.20
3	60.0	1.00	0.16
4	240.0	4.00	0.16
5	360.0	6.00	0.09
6	217.7	3.63	0.02
7	480.0	8.00	0.02
8	20.9	0.35	0.01
9	87.9	1.47	0.01
10	92.1	1.53	0.01

SCALE: Linear

DATE: 01-27-87

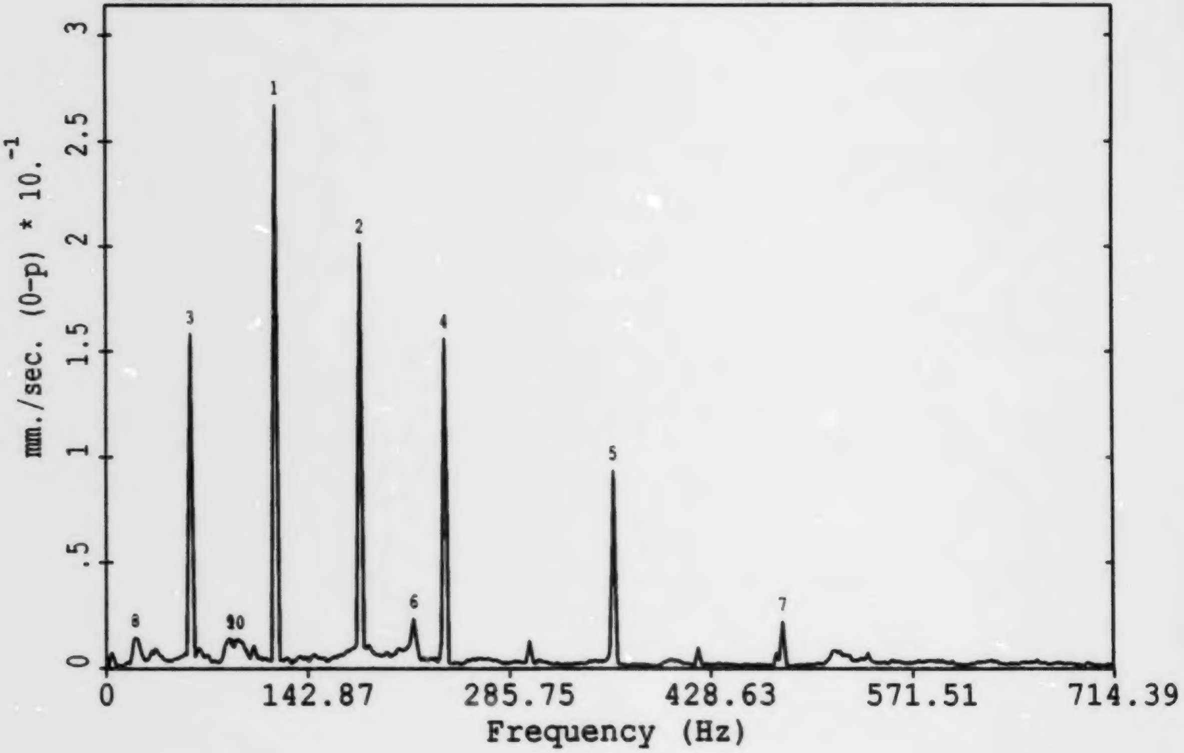


FIGURE 32

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.23
2	240.0	4.00	0.16
3	120.0	2.00	0.14
4	87.9	1.47	0.11
5	94.9	1.58	0.10
6	360.0	6.00	0.07
7	300.0	5.00	0.05
8	104.6	1.74	0.04
9	108.8	1.81	0.03
10	540.0	9.00	0.03

SCALE: Linear

DATE: 01-27-87

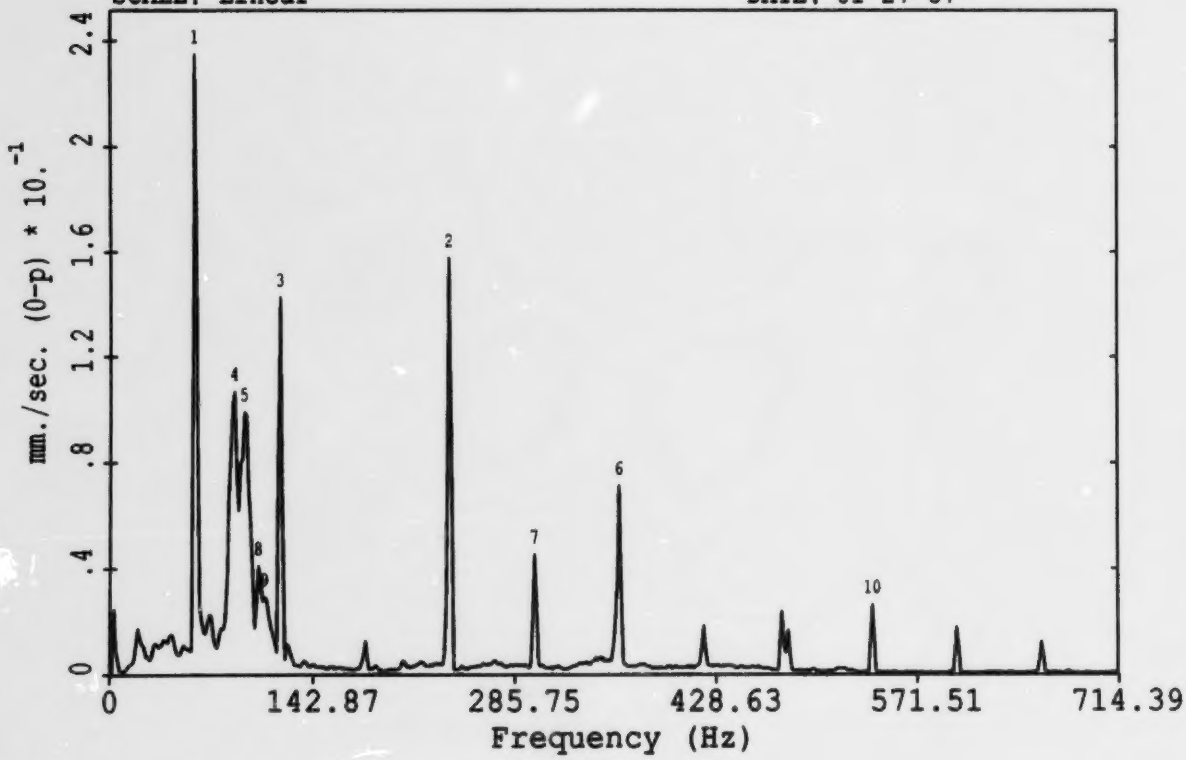


FIGURE 33

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.79
2	240.0	4.00	0.38
3	60.0	1.00	0.12
4	360.0	6.00	0.08
5	180.0	3.00	0.06
6	19.5	0.33	0.03
7	217.7	3.63	0.03
8	125.6	2.09	0.03
9	420.0	7.00	0.03

SCALE: Linear DATE: 01-27-87

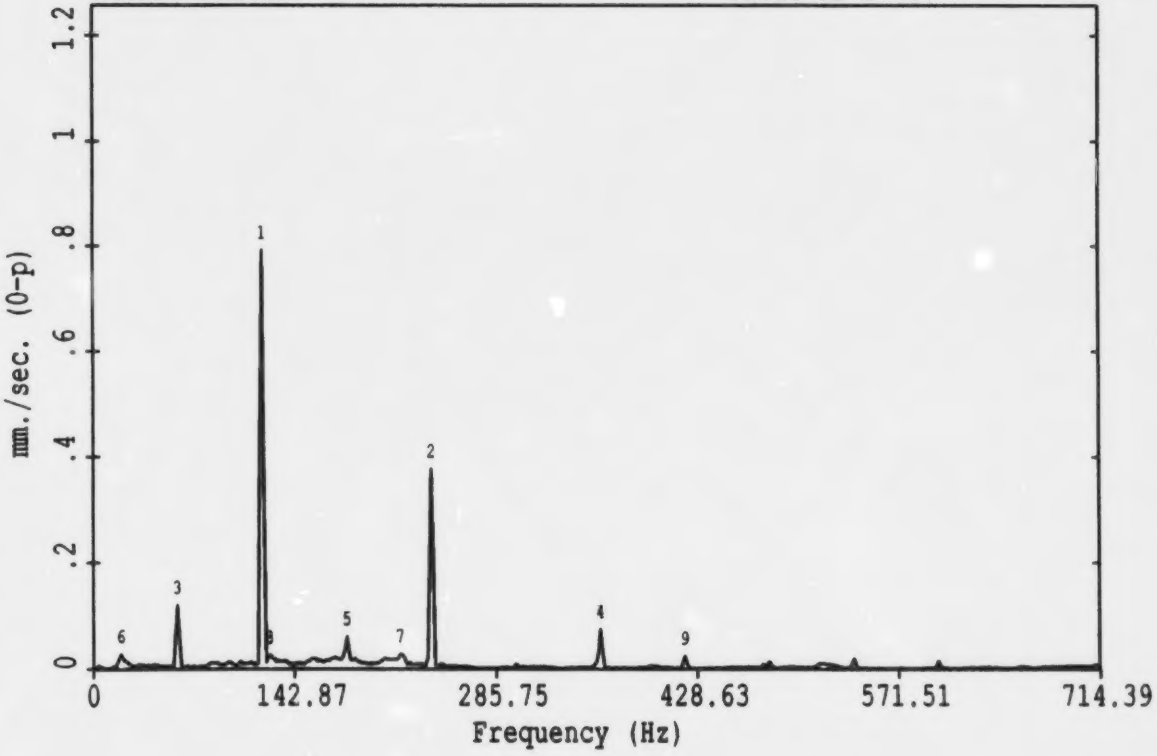


FIGURE 34

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	0.54
2	240.0	4.00	0.38
3	60.0	1.00	0.24
4	217.7	3.63	0.06
5	180.0	3.00	0.06
6	360.0	6.00	0.04
7	300.0	5.00	0.04
8	212.1	3.53	0.04
9	420.0	7.00	0.04
10	206.5	3.44	0.03

SCALE: Linear

DATE: 01-27-87

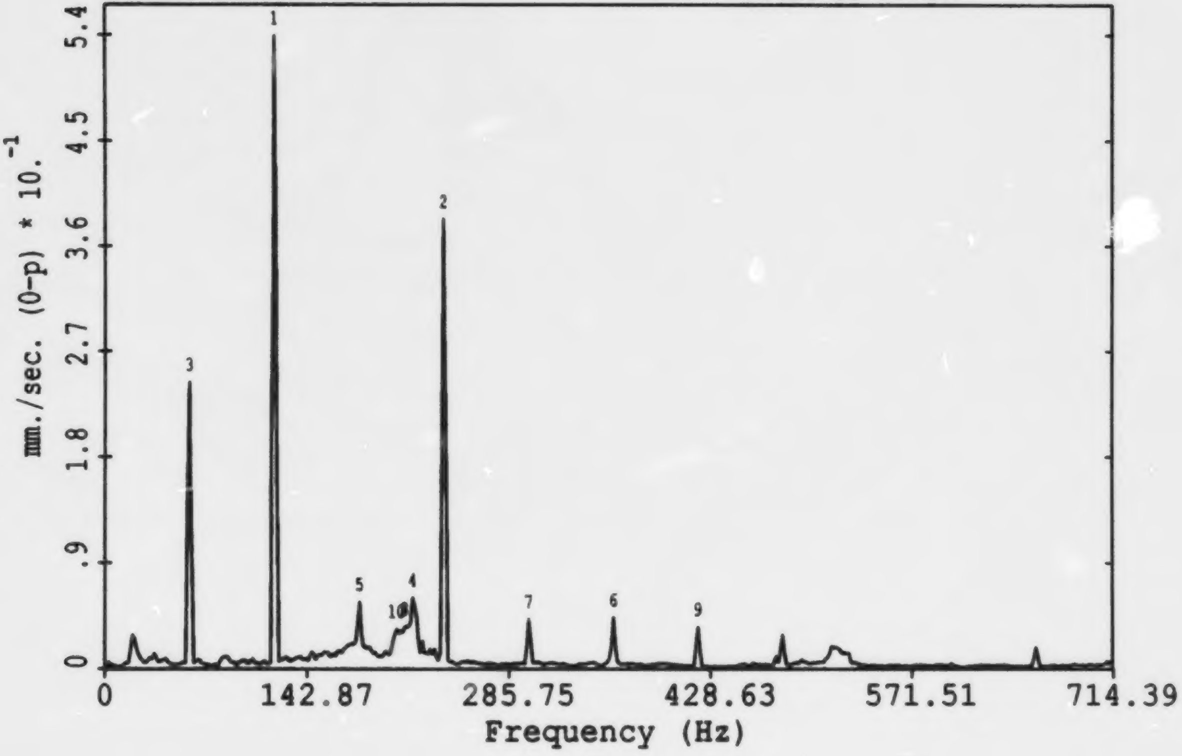


FIGURE 35

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	240.0	4.00	0.19
2	86.5	1.44	0.09
3	60.0	1.00	0.09
4	120.0	2.00	0.08
5	360.0	6.00	0.05
6	125.6	2.09	0.02
7	180.0	3.00	0.02
8	104.6	1.74	0.02
9	97.7	1.63	0.02
10	19.5	0.33	0.02

SCALE: Linear

DATE: 01-27-87

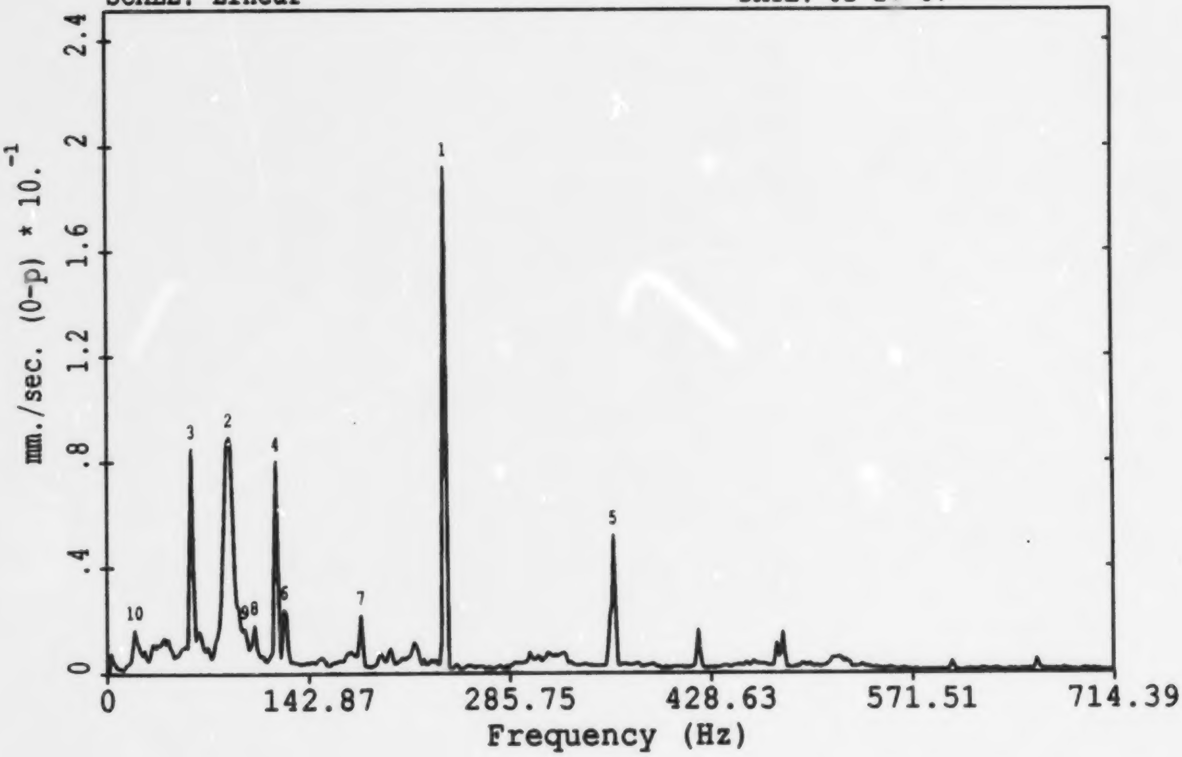
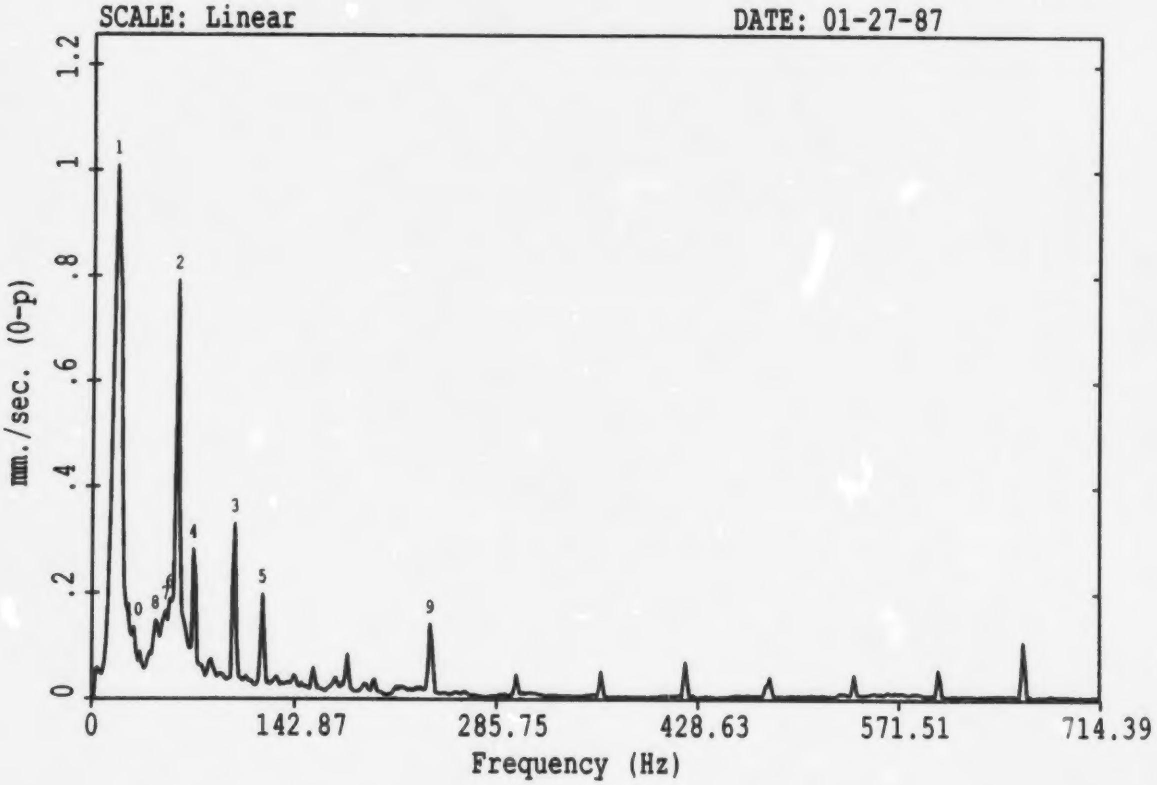


FIGURE 36

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	16.7	0.28	1.01
2	60.0	1.00	0.79
3	100.5	1.67	0.33
4	71.2	1.19	0.28
5	120.0	2.00	0.20
6	54.4	0.91	0.19
7	51.6	0.86	0.17
8	44.6	0.74	0.15
9	238.6	3.98	0.14
10	29.3	0.49	0.14



SCALE: Linear

DATE: 01-27-87

FIGURE 37

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.88
2	15.3	0.26	0.48
3	54.4	0.91	0.23
4	100.5	1.67	0.22
5	29.3	0.49	0.16
6	23.7	0.40	0.16
7	44.6	0.74	0.16
8	71.2	1.19	0.15
9	26.5	0.44	0.14
10	40.5	0.67	0.14

SCALE: Linear

DATE: 01-27-87

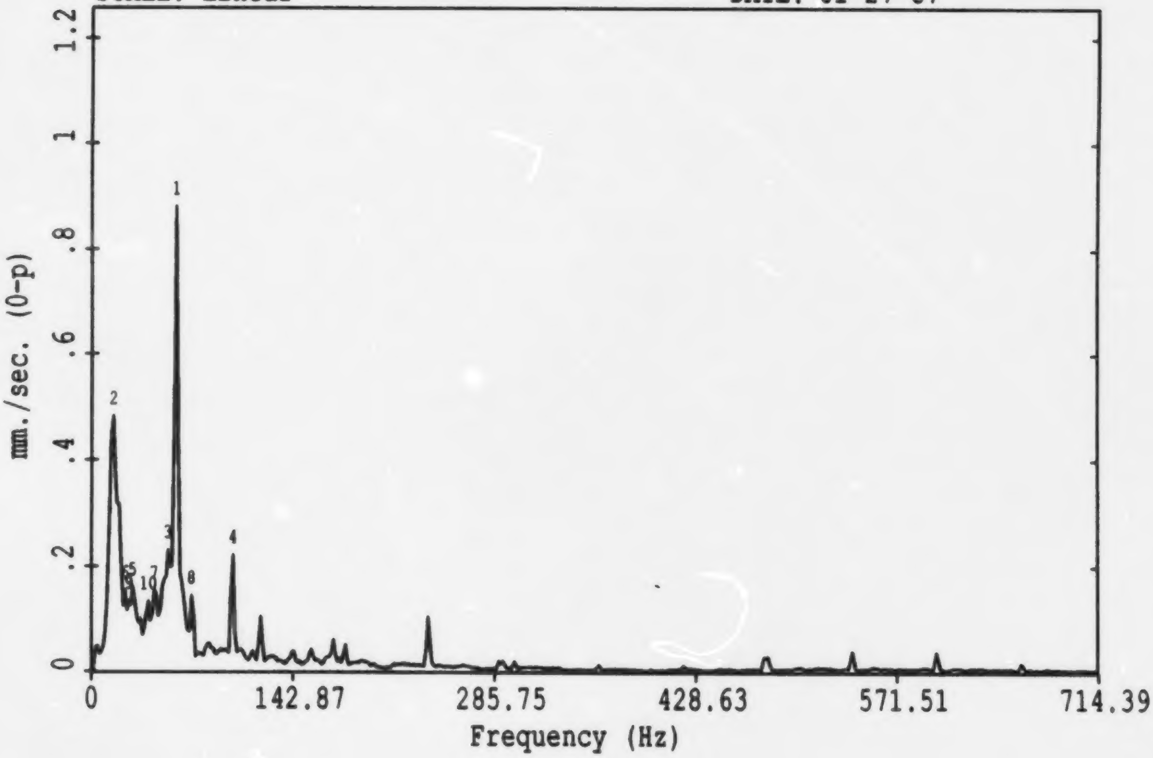


FIGURE 38

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	1.21
2	40.5	0.67	0.35
3	36.3	0.60	0.30
4	23.7	0.40	0.27
5	29.3	0.49	0.18
6	600.0	10.00	0.16
7	238.6	3.98	0.16
8	44.6	0.74	0.13
9	360.0	6.00	0.11
10	660.0	11.00	0.11

SCALE: Linear DATE: 01-27-87

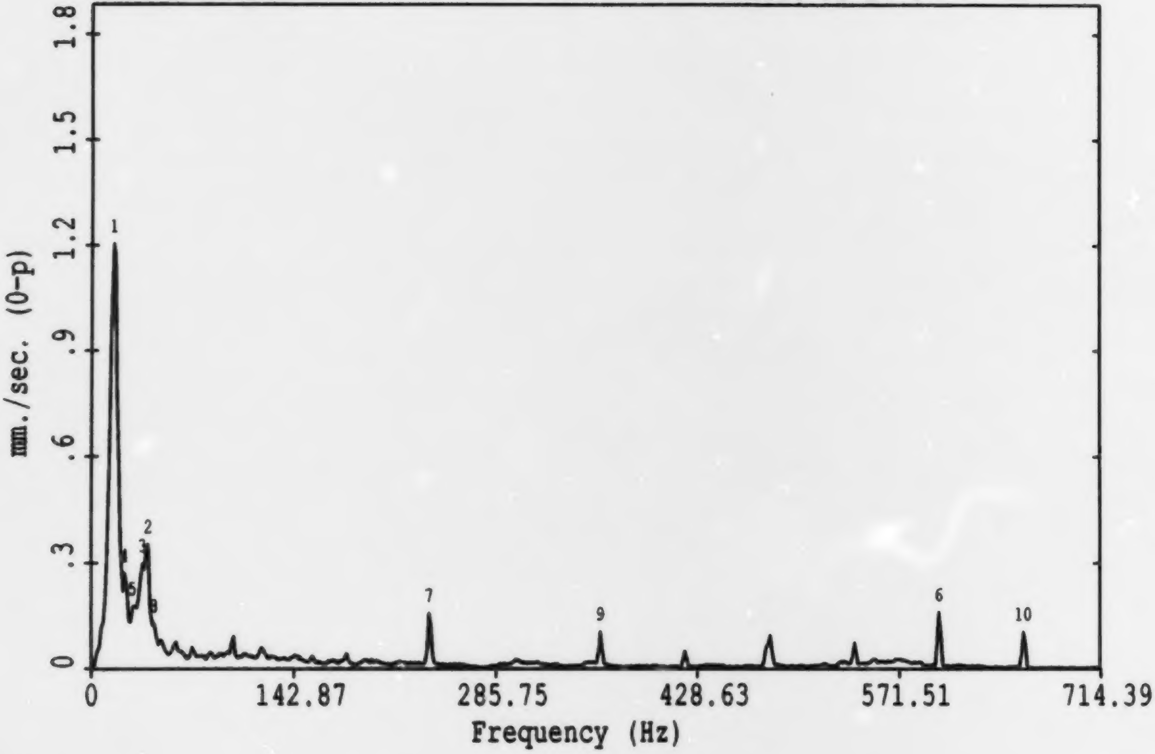


FIGURE 39

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	0.90
2	19.5	0.33	0.81
3	60.0	1.00	0.61
4	120.0	2.00	0.32
5	55.8	0.93	0.29
6	108.8	1.81	0.26
7	51.6	0.86	0.24
8	27.9	0.47	0.18
9	238.6	3.98	0.15
10	660.0	11.00	0.14

SCALE: Linear DATE: 01-27-87

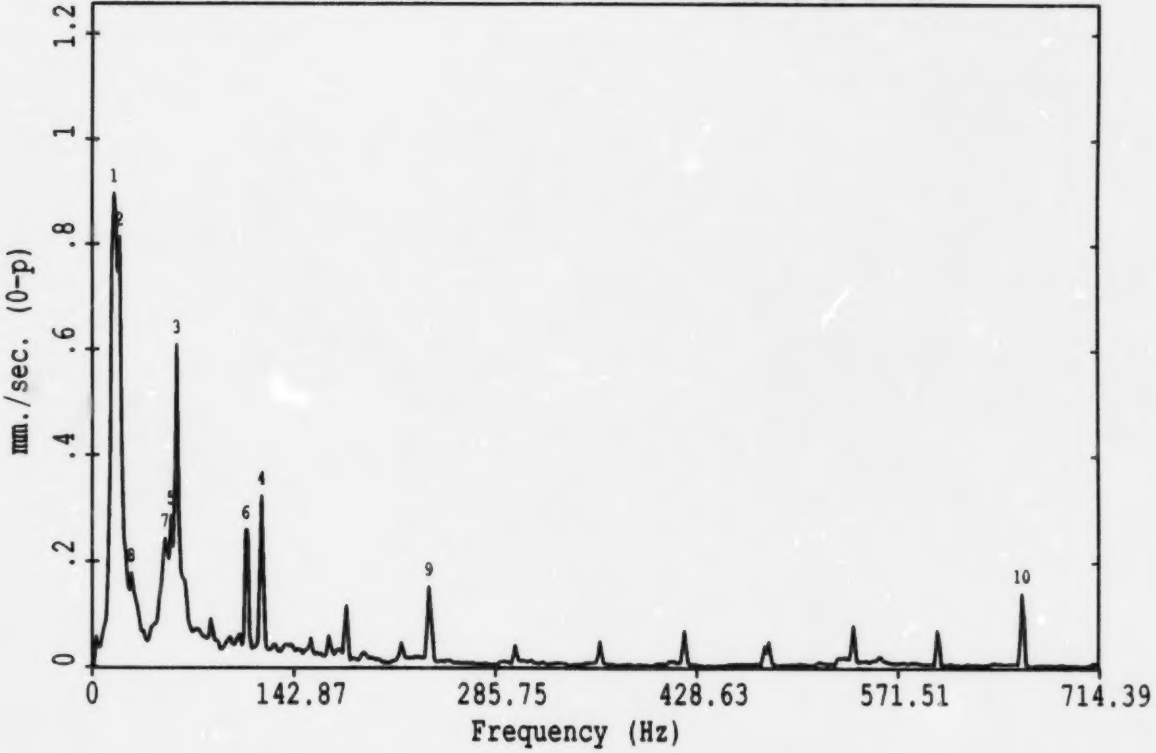


FIGURE 40

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.79
2	14.0	0.23	0.58
3	19.5	0.33	0.29
4	51.6	0.86	0.26
5	55.8	0.93	0.21
6	30.7	0.51	0.20
7	27.9	0.47	0.15
8	40.5	0.67	0.13
9	108.8	1.81	0.12
10	238.6	3.98	0.12

SCALE: Linear

DATE: 01-27-87

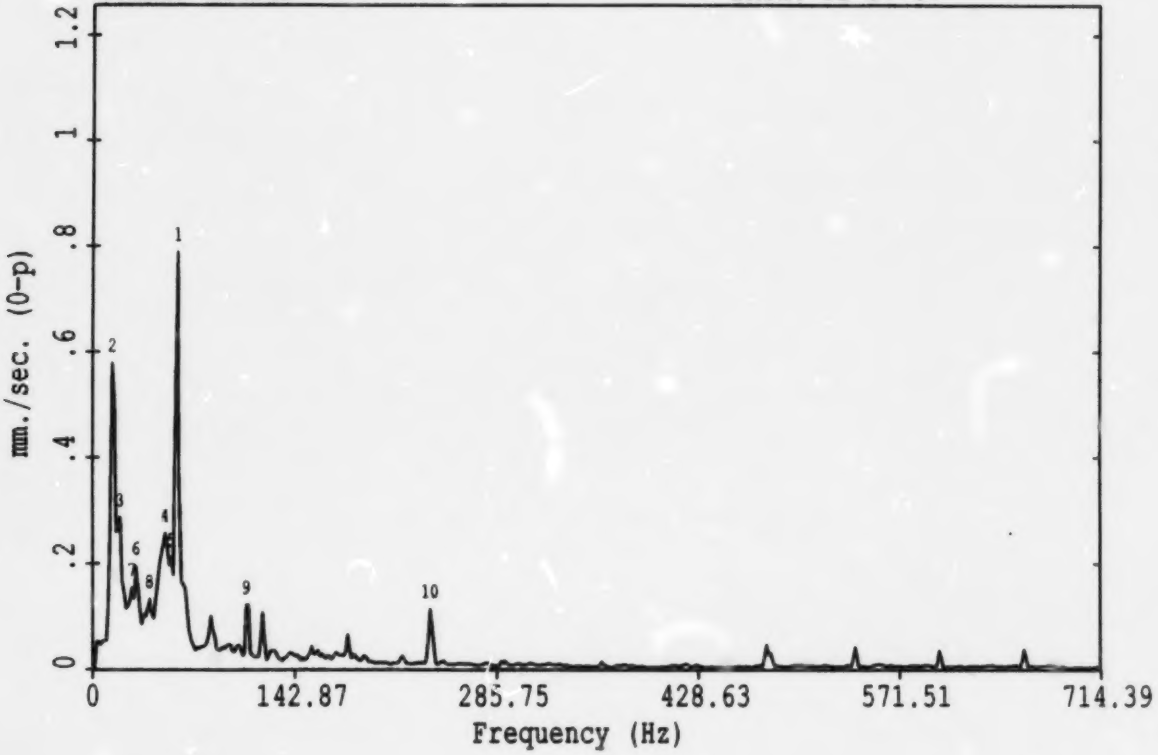


FIGURE 41

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	1.29
2	19.5	0.33	0.61
3	40.5	0.67	0.44
4	36.3	0.60	0.28
5	23.7	0.40	0.25
6	32.1	0.53	0.19
7	600.0	10.00	0.19
8	29.3	0.49	0.17
9	540.0	9.00	0.16
10	660.0	11.00	0.16

SCALE: Linear

DATE: 01-27-87

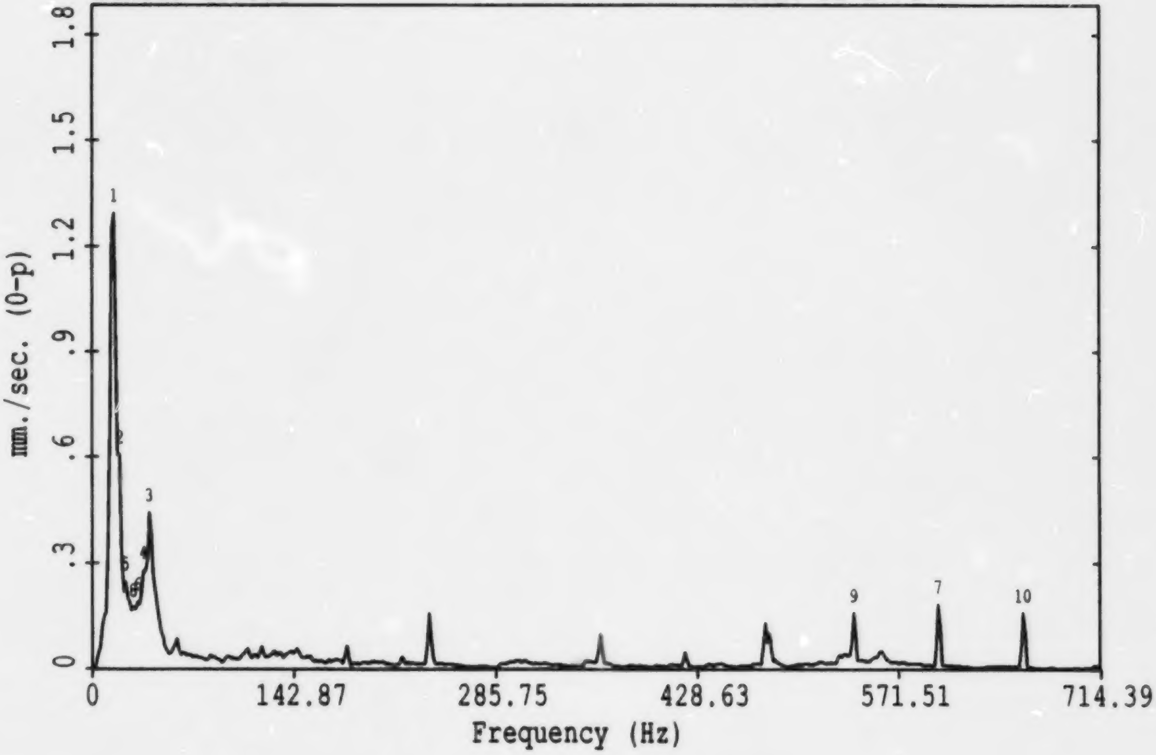


FIGURE 42

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	18.1	0.30	1.04
2	120.0	2.00	0.40
3	60.0	1.00	0.24
4	115.8	1.93	0.23
5	53.0	0.88	0.22
6	65.6	1.09	0.18
7	660.0	11.00	0.17
8	29.3	0.49	0.15
9	238.6	3.98	0.14
10	180.0	3.00	0.12

SCALE: Linear DATE: 01-27-87

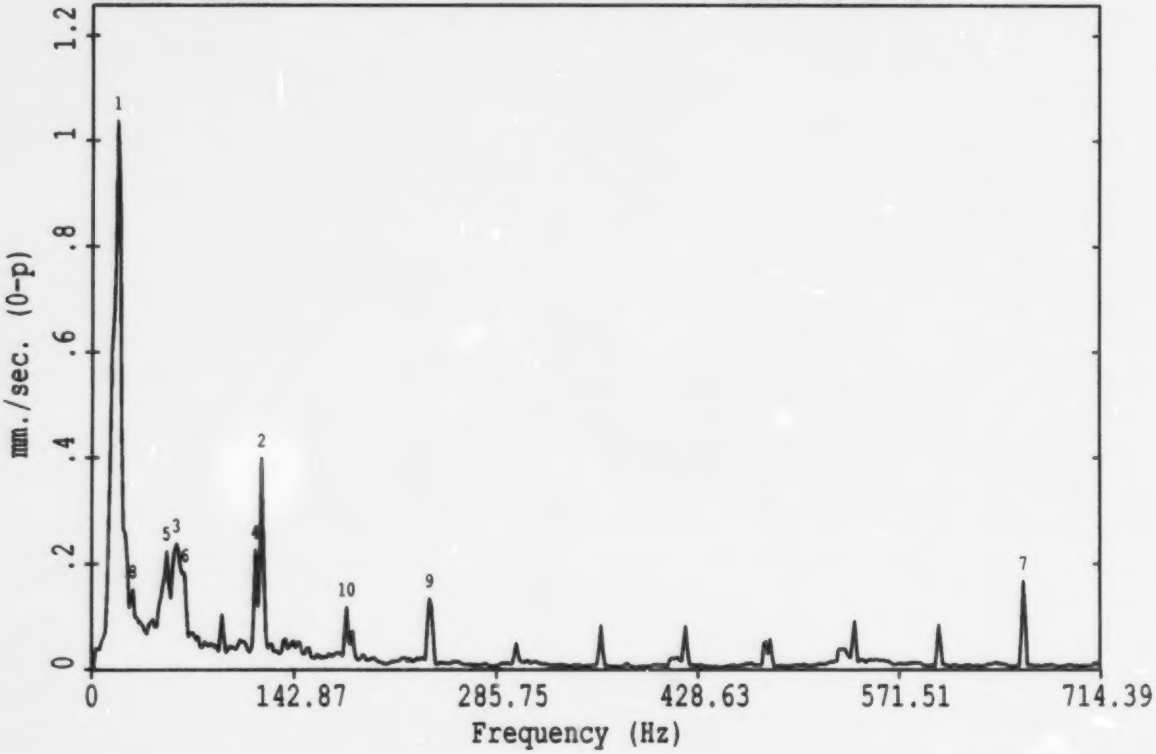
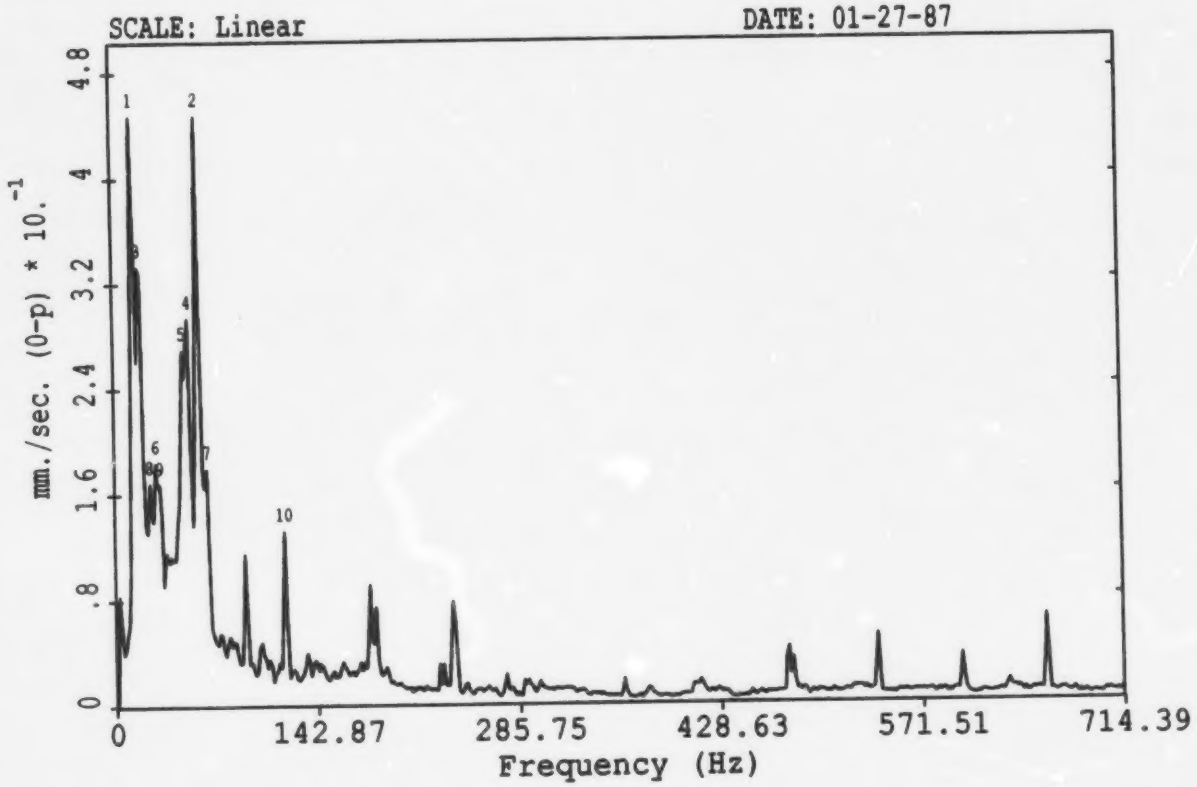


FIGURE 43

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 15 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	14.0	0.23	0.45
2	60.0	1.00	0.45
3	18.1	0.30	0.33
4	53.0	0.88	0.29
5	48.8	0.81	0.27
6	29.3	0.49	0.18
7	65.6	1.09	0.18
8	25.1	0.42	0.17
9	32.1	0.53	0.17
10	120.0	2.00	0.13


SCALE: Linear

DATE: 01-27-87

FIGURE 44

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	14.0	0.23	0.98
2	40.5	0.67	0.43
3	23.7	0.40	0.28
4	600.0	10.00	0.21
5	29.3	0.49	0.21
6	540.0	9.00	0.20
7	660.0	11.00	0.18
8	360.0	6.00	0.17
9	477.2	7.95	0.16
10	238.6	3.98	0.13

SCALE: Linear

DATE: 01-27-87

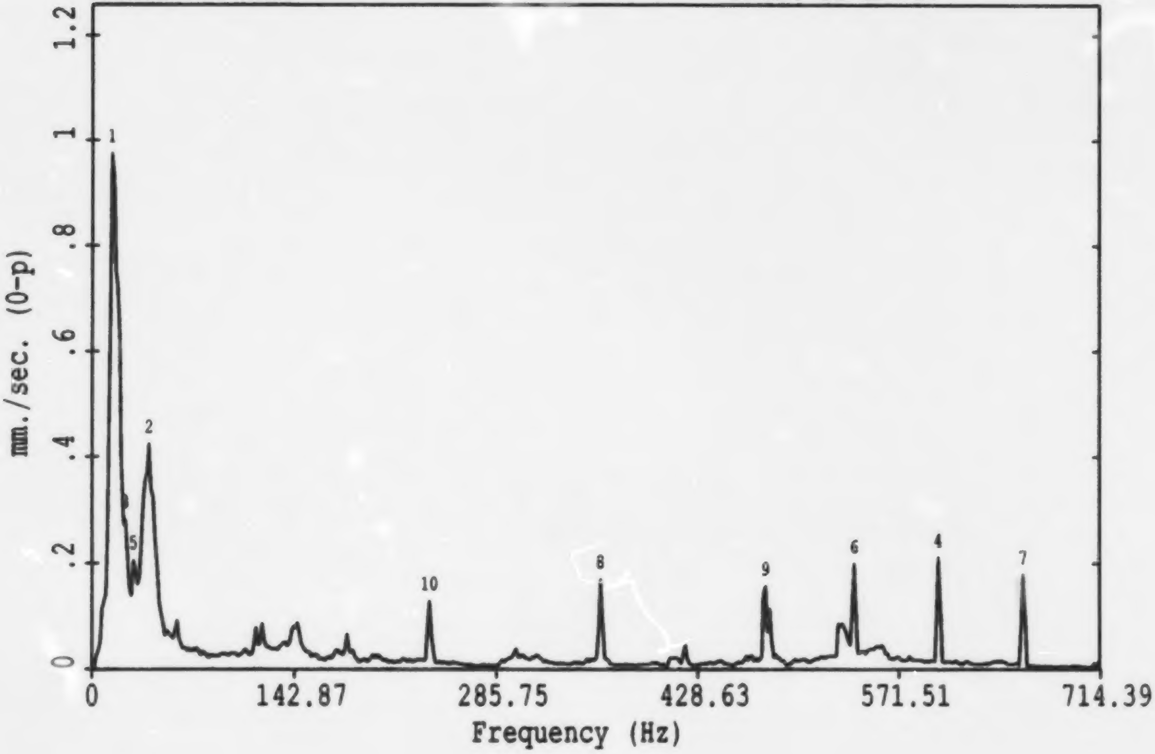


FIGURE 45

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	0.57
2	14.0	0.23	0.53
3	120.0	2.00	0.52
4	60.0	1.00	0.32
5	100.5	1.67	0.30
6	660.0	11.00	0.19
7	26.5	0.44	0.19
8	65.6	1.09	0.17
9	360.0	6.00	0.15
10	180.0	3.00	0.14

SCALE: Linear DATE: 01-27-87

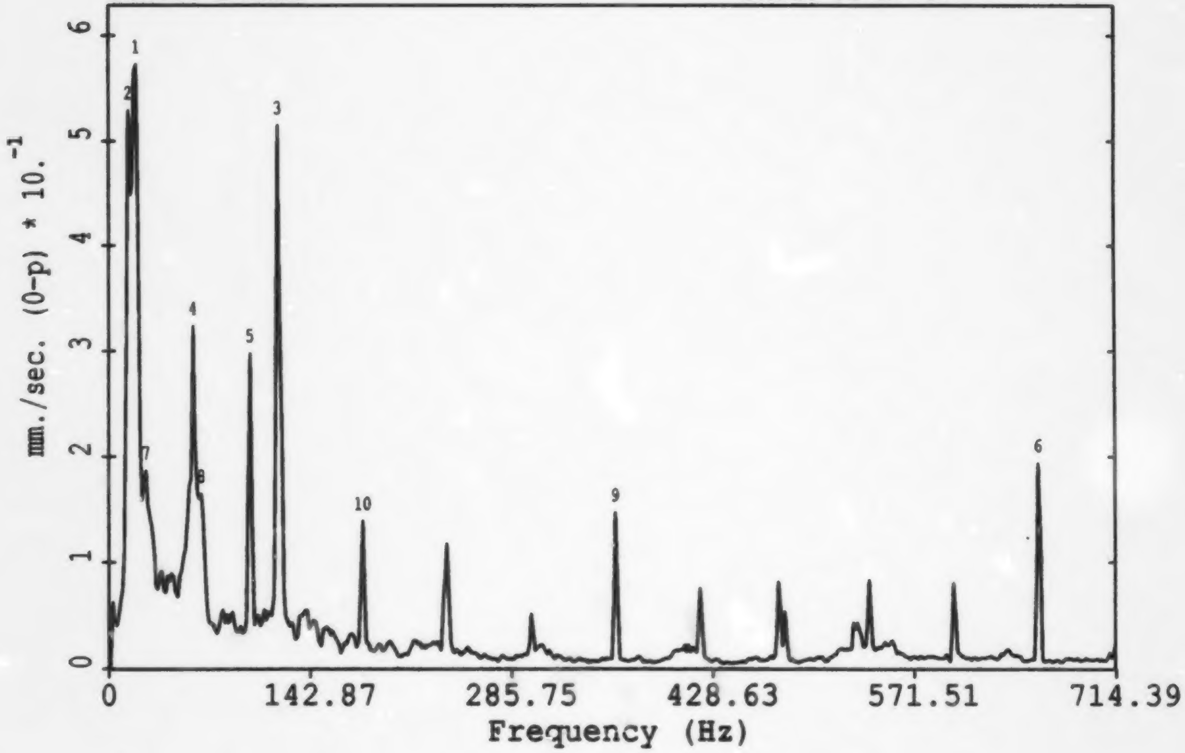


FIGURE 46

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	14.0	0.23	0.42
2	60.0	1.00	0.24
3	50.2	0.84	0.23
4	27.9	0.47	0.21
5	32.1	0.53	0.21
6	100.5	1.67	0.17
7	64.2	1.07	0.16
8	120.0	2.00	0.16
9	43.3	0.72	0.14
10	180.0	3.00	0.12

SCALE: Linear DATE: 01-27-87

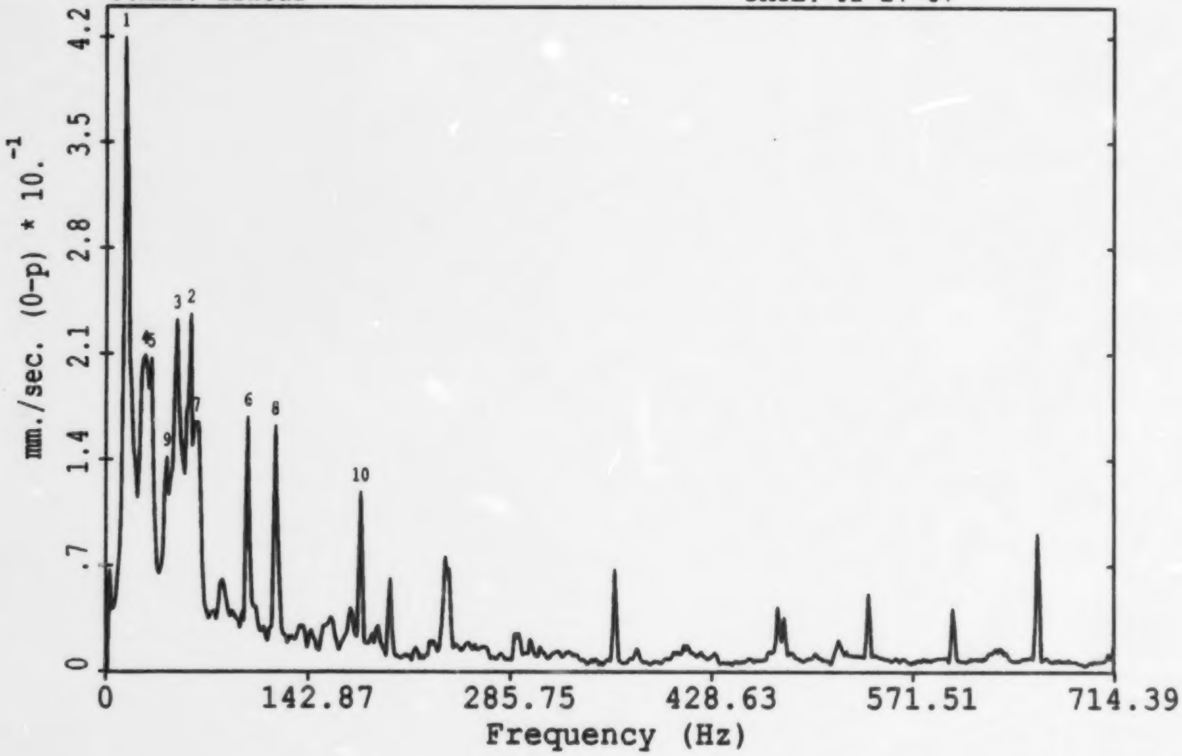


FIGURE 47

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	14.0	0.23	0.92
2	19.5	0.33	0.44
3	41.9	0.70	0.35
4	360.0	6.00	0.32
5	36.3	0.60	0.31
6	32.1	0.53	0.25
7	600.0	10.00	0.25
8	475.8	7.93	0.24
9	25.1	0.42	0.23
10	540.0	9.00	0.23

SCALE: Linear DATE: 01-27-87

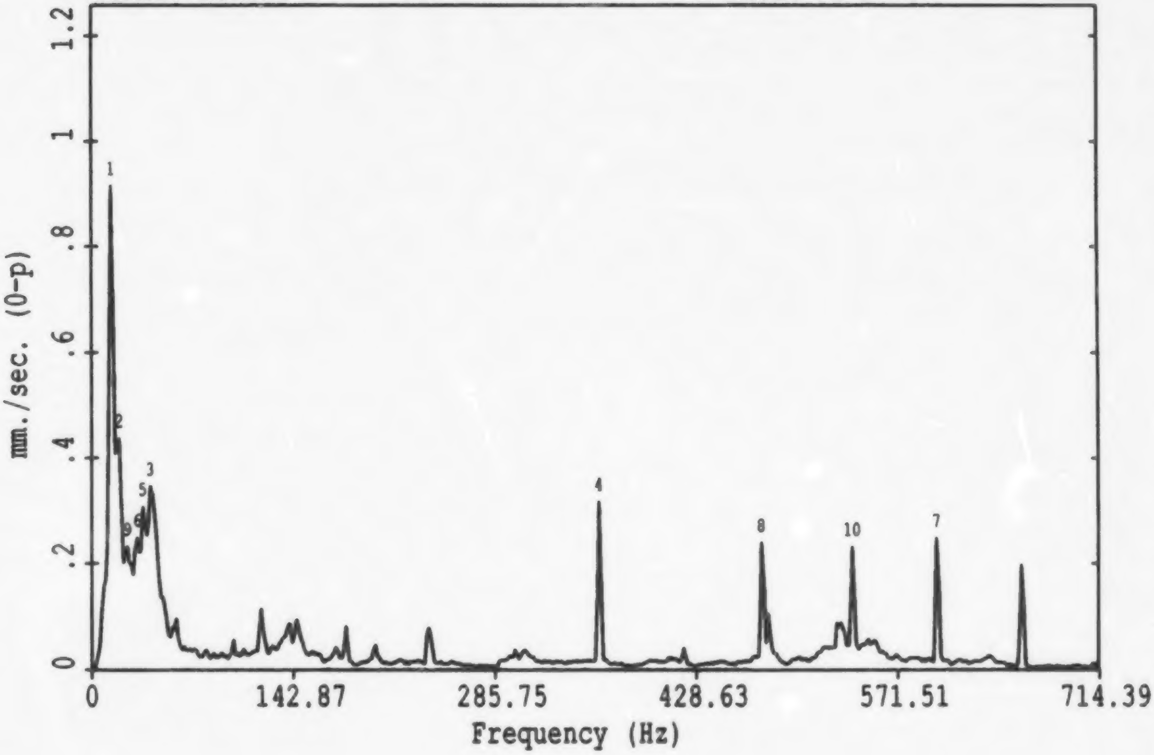
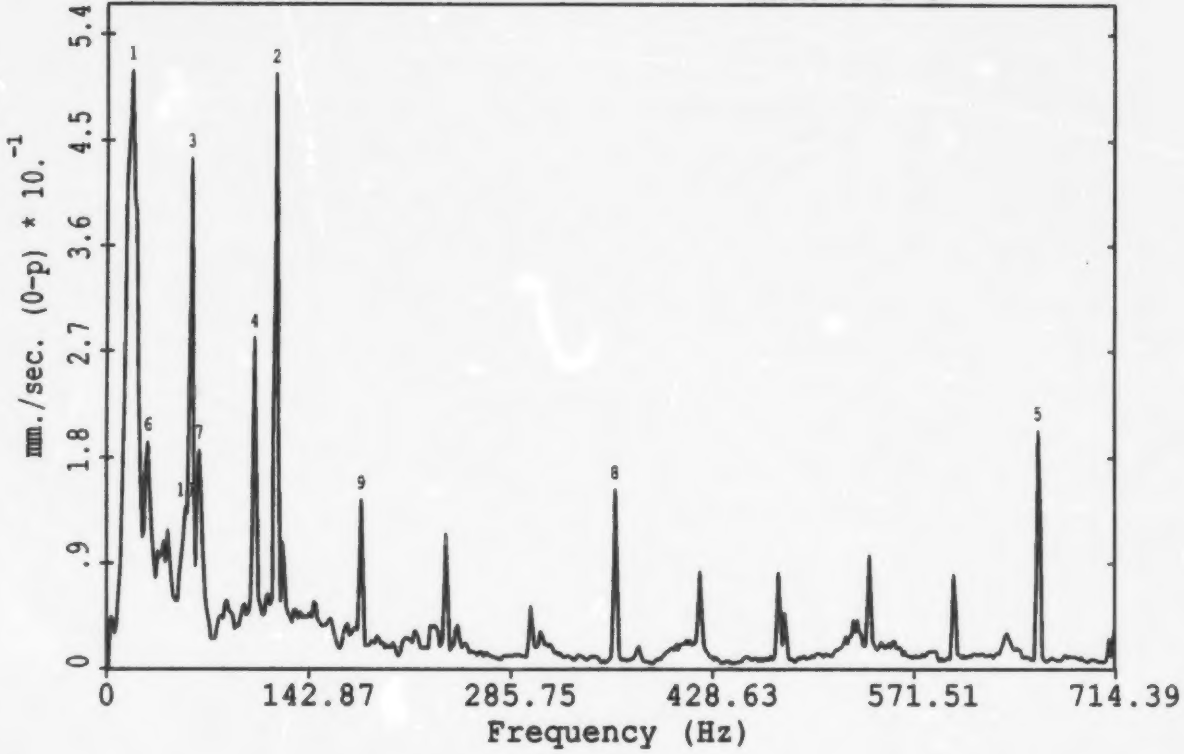


FIGURE 48

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	18.1	0.30	0.51
2	120.0	2.00	0.51
3	60.0	1.00	0.44
4	104.6	1.74	0.28
5	660.0	11.00	0.20
6	29.3	0.49	0.19
7	65.6	1.09	0.19
8	360.0	6.00	0.15
9	180.0	3.00	0.14
10	55.8	0.93	0.14



SCALE: Linear

DATE: 01-27-87

FIGURE 49

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	0.39
2	14.0	0.23	0.37
3	29.3	0.49	0.26
4	65.6	1.09	0.20
5	19.5	0.33	0.17
6	120.0	2.00	0.17
7	25.1	0.42	0.15
8	43.3	0.72	0.14
9	55.8	0.93	0.13
10	53.0	0.88	0.13

SCALE: Linear

DATE: 01-27-87

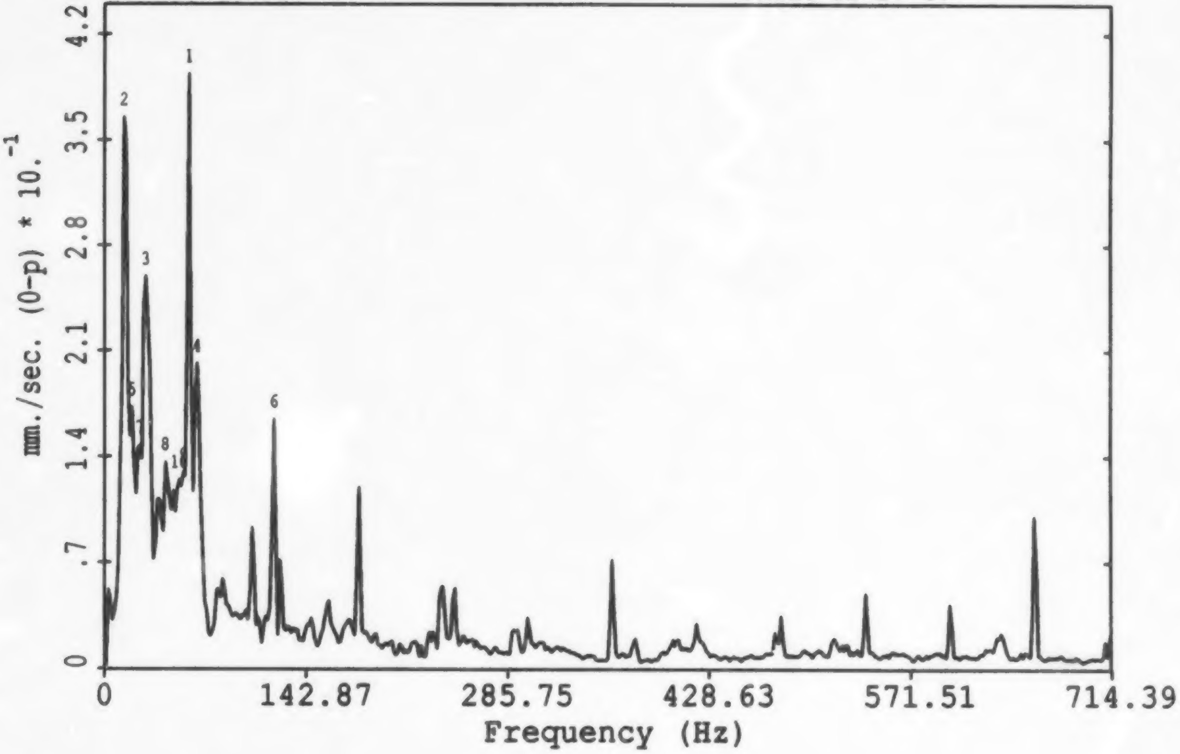


FIGURE 50

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Casing Velocity Axial
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	15.3	0.26	0.70
2	37.7	0.63	0.39
3	43.3	0.72	0.38
4	30.7	0.51	0.31
5	360.0	6.00	0.28
6	600.0	10.00	0.26
7	540.0	9.00	0.24
8	475.8	7.93	0.24
9	660.0	11.00	0.22
10	60.0	1.00	0.13

SCALE: Linear

DATE: 01-27-87

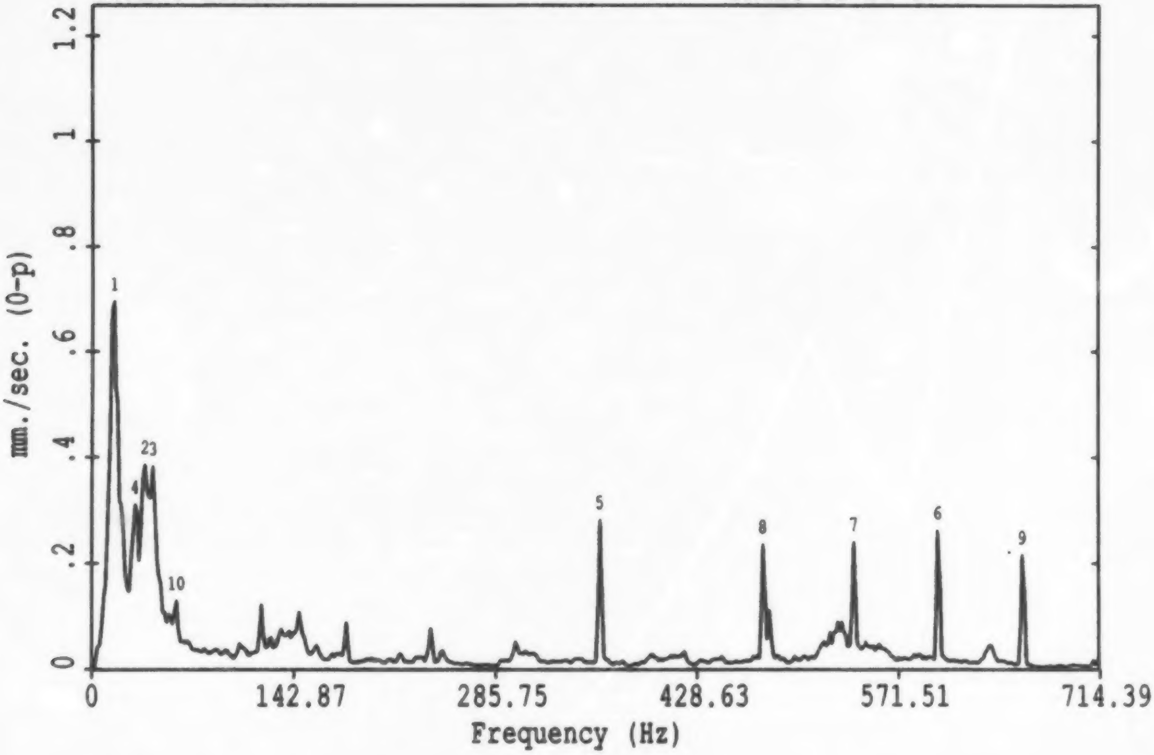


FIGURE 51

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	17.04
2	60.0	1.00	13.38
3	180.0	3.00	8.87
4	240.0	4.00	4.24
5	420.0	7.00	1.87
6	540.0	9.00	1.67
7	480.0	8.00	1.56
8	300.0	5.00	1.01
9	660.0	11.00	0.93
10	600.0	10.00	0.83

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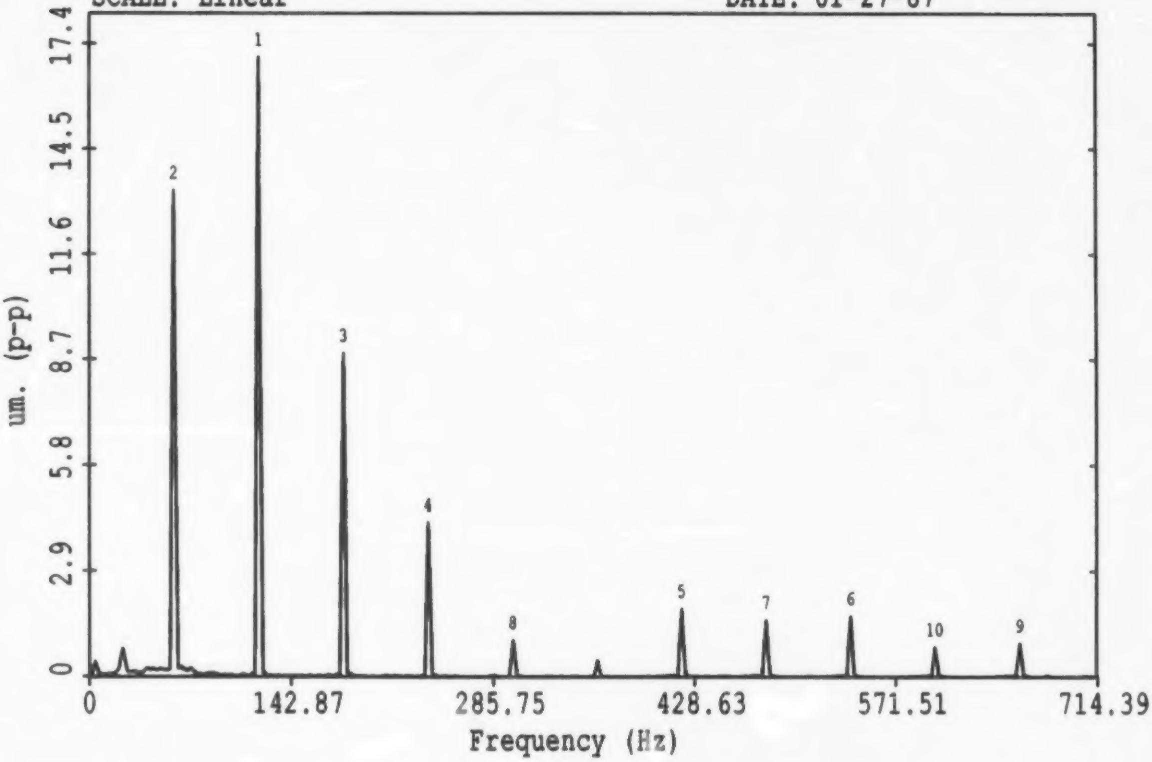


FIGURE 52

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	16.25
2	120.0	2.00	12.78
3	180.0	3.00	6.57
4	240.0	4.00	2.46
5	420.0	7.00	1.93
6	540.0	9.00	1.76
7	360.0	6.00	1.34
8	480.0	8.00	1.33
9	660.0	11.00	0.82
10	300.0	5.00	0.79

SCALE: Linear DATE: 01-27-87

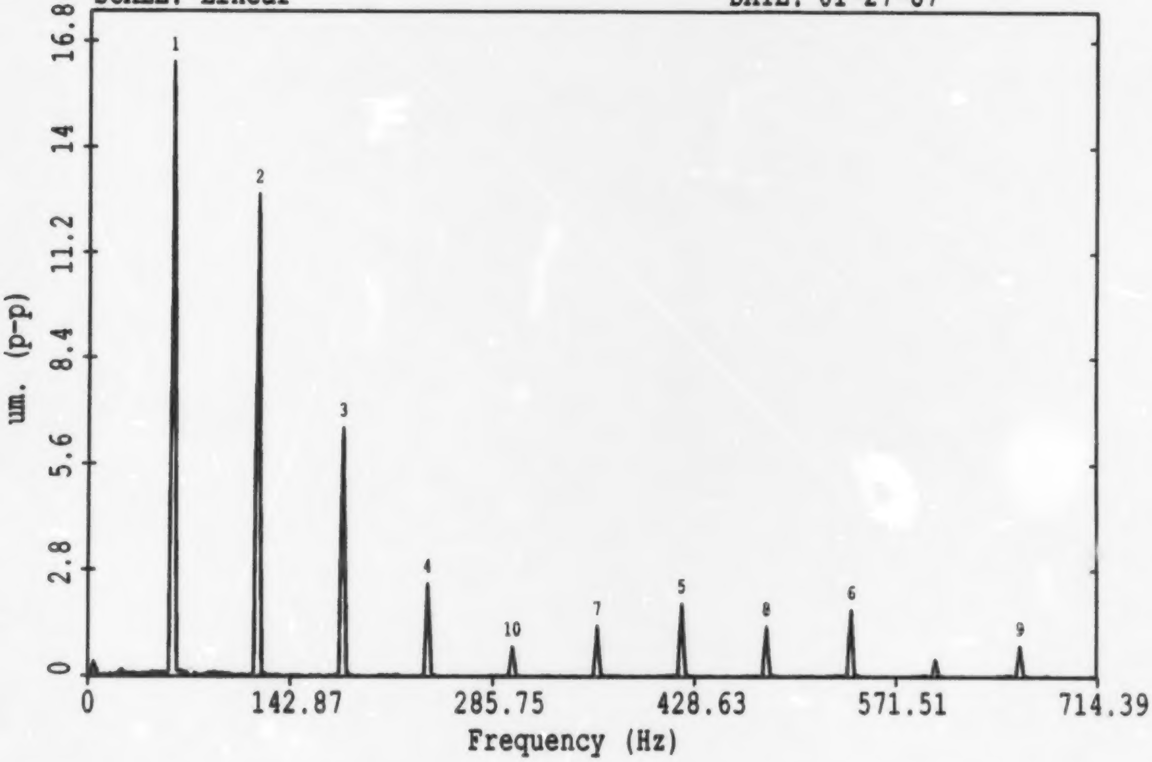


FIGURE 53

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	17.72
2	120.0	2.00	3.78
3	180.0	3.00	3.41
4	240.0	4.00	3.37
5	300.0	5.00	3.36
6	480.0	8.00	2.96
7	420.0	7.00	2.40
8	540.0	9.00	1.52
9	660.0	11.00	1.49
10	360.0	6.00	1.31

SCALE: Linear

DATE: 01-27-87

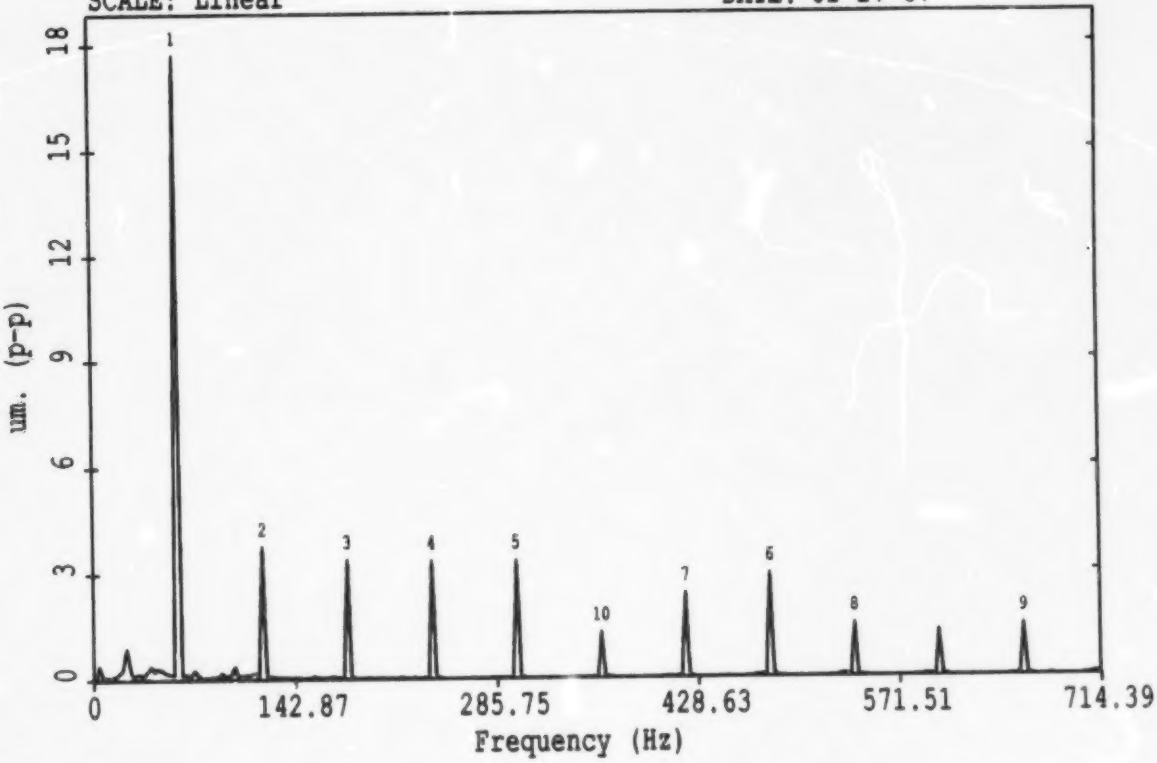


FIGURE 54

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	13.87
2	120.0	2.00	6.82
3	180.0	3.00	3.54
4	240.0	4.00	3.49
5	300.0	5.00	3.29
6	480.0	8.00	3.00
7	420.0	7.00	2.23
8	660.0	11.00	1.74
9	540.0	9.00	1.49
10	360.0	6.00	1.40

SCALE: Linear DATE: 01-27-87

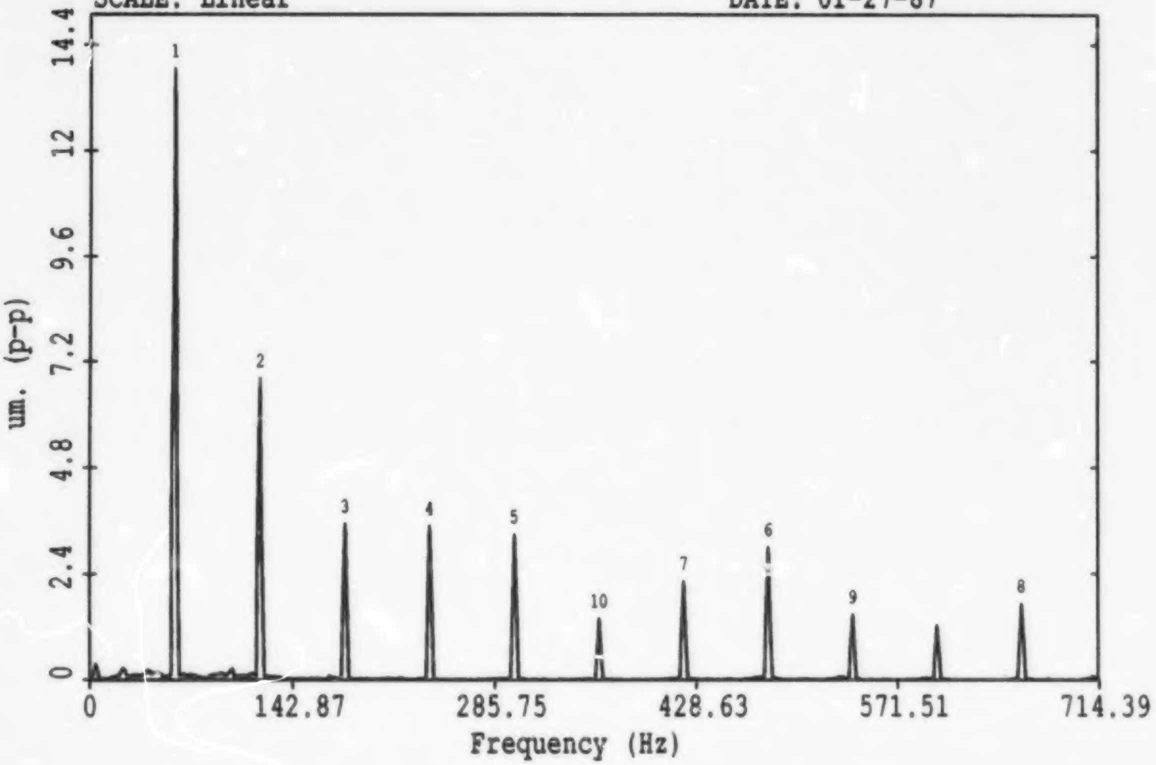


FIGURE 55

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	16.80
2	60.0	1.00	12.08
3	180.0	3.00	8.84
4	240.0	4.00	4.05
5	420.0	7.00	1.79
6	540.0	9.00	1.67
7	480.0	8.00	1.55
8	660.0	11.00	0.96
9	300.0	5.00	0.95
10	600.0	10.00	0.74

SCALE: Linear

DATE: 01-27-87

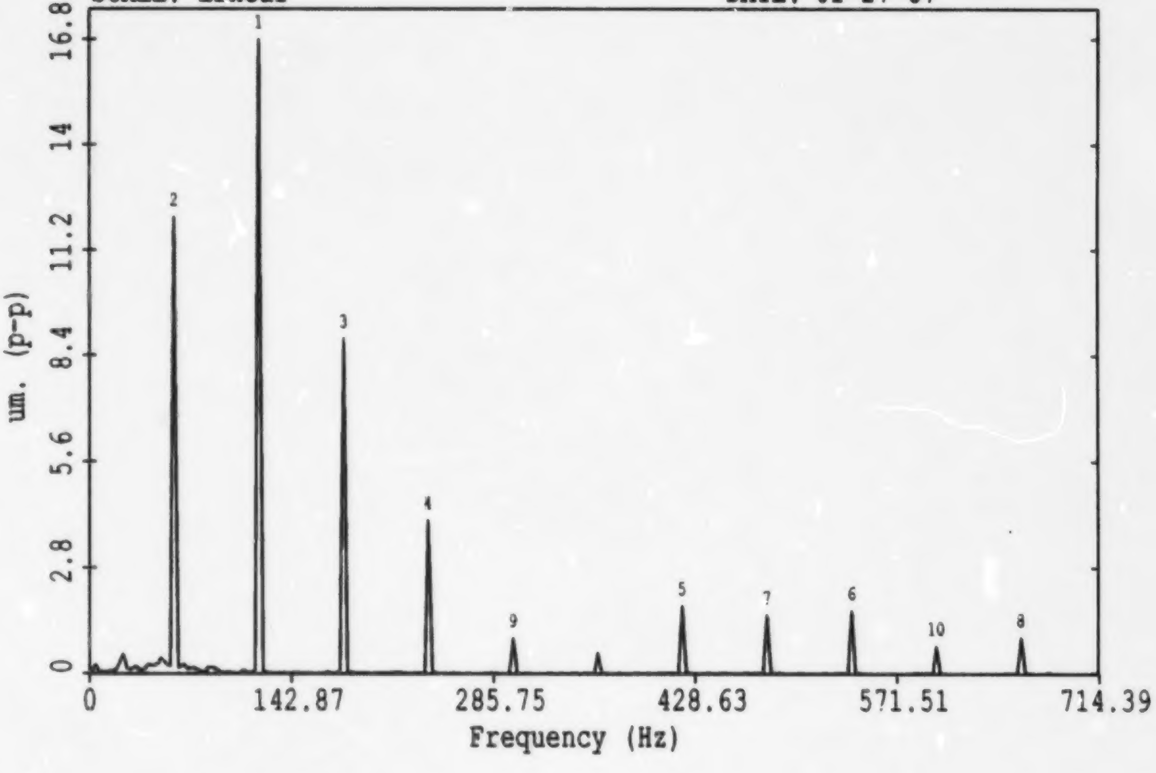


FIGURE 56

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	15.54
2	120.0	2.00	12.46
3	180.0	3.00	6.08
4	240.0	4.00	2.13
5	420.0	7.00	1.98
6	540.0	9.00	1.74
7	360.0	6.00	1.50
8	480.0	8.00	1.27
9	660.0	11.00	0.84
10	300.0	5.00	0.74

SCALE: Linear DATE: 01-27-87

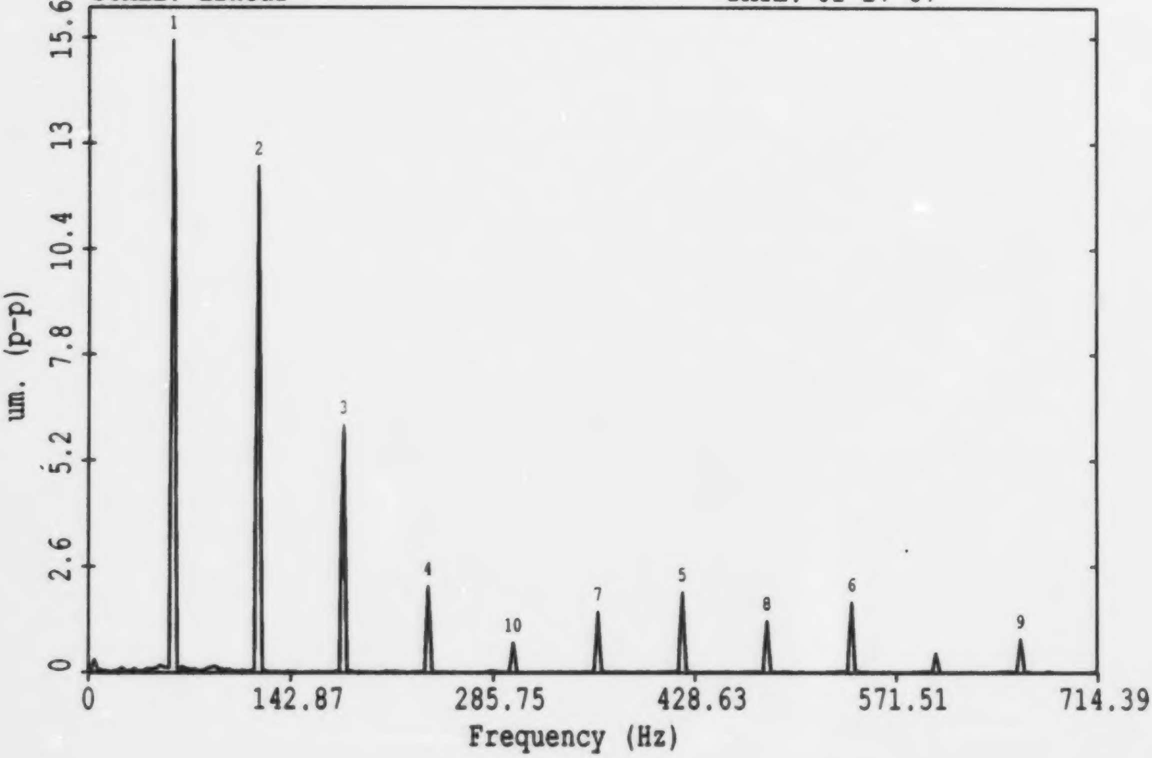


FIGURE 57

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	17.84
2	180.0	3.00	3.41
3	300.0	5.00	3.31
4	240.0	4.00	3.28
5	120.0	2.00	3.12
6	480.0	8.00	2.91
7	420.0	7.00	2.42
8	540.0	9.00	1.53
9	660.0	11.00	1.44
10	360.0	6.00	1.36

SCALE: Linear

DATE: 01-27-87

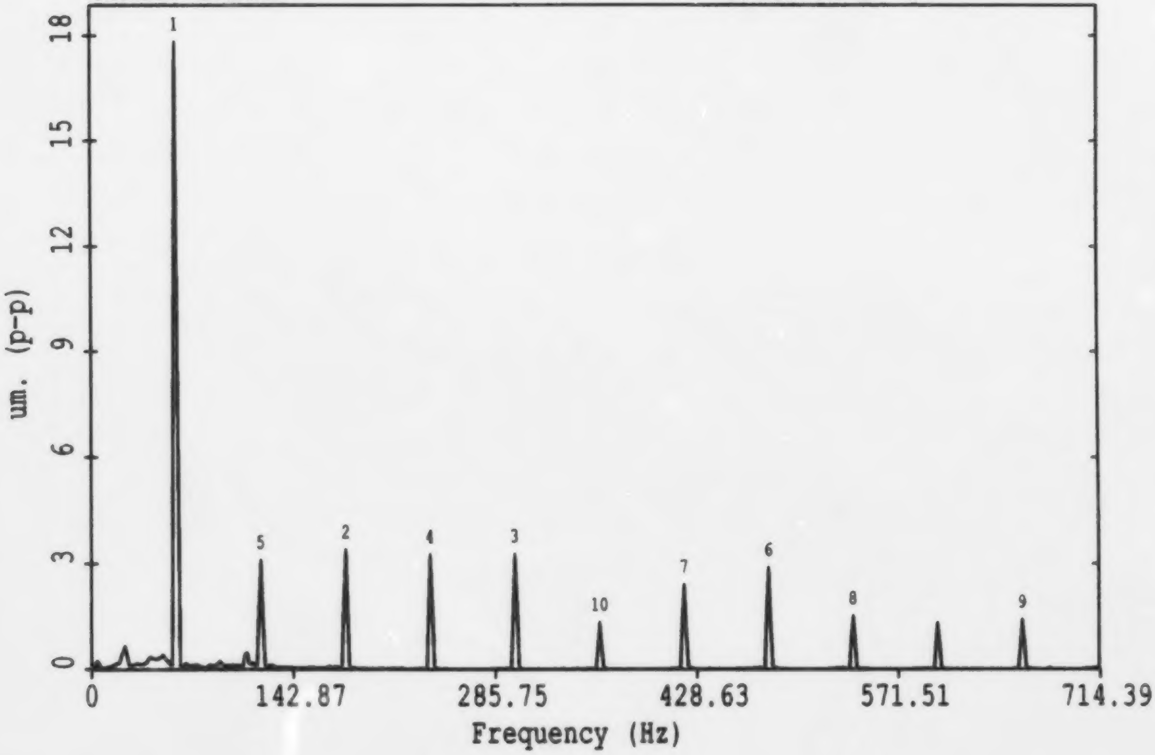


FIGURE 58

Darlington GS Standby Generator #3 AC Generator

SIGNAL	:	Inboard Brg. Shaft Displacement X-Axis
SPEED	:	3600 r.p.m.
PROCESS CONDITION	:	Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	13.98
2	120.0	2.00	6.59
3	180.0	3.00	3.58
4	240.0	4.00	3.54
5	300.0	5.00	3.28
6	480.0	8.00	3.05
7	420.0	7.00	2.28
8	660.0	11.00	1.71
9	540.0	9.00	1.50
10	360.0	6.00	1.37

SCALE: Linear

DATE: 01-27-87

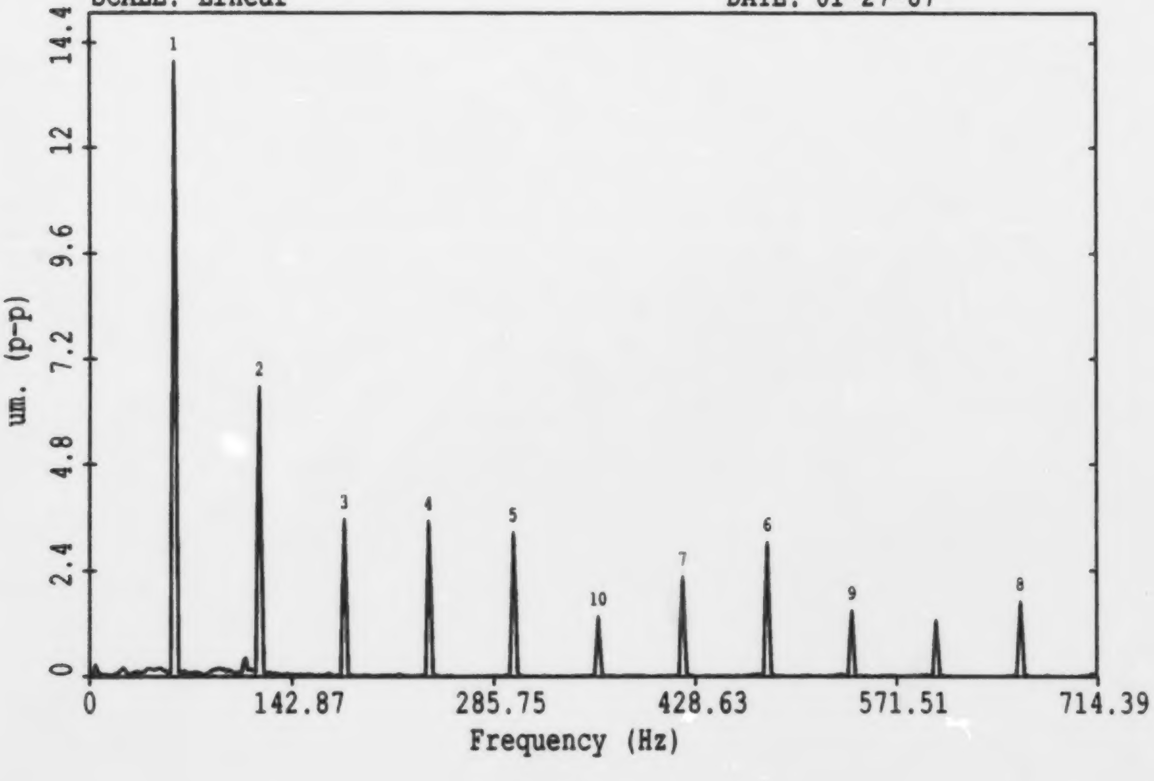


FIGURE 59

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	16.32
2	60.0	1.00	11.76
3	180.0	3.00	8.68
4	240.0	4.00	3.86
5	420.0	7.00	1.77
6	540.0	9.00	1.66
7	480.0	8.00	1.52
8	660.0	11.00	0.96
9	300.0	5.00	0.94
10	600.0	10.00	0.67

SCALE: Linear

DATE: 01-27-87

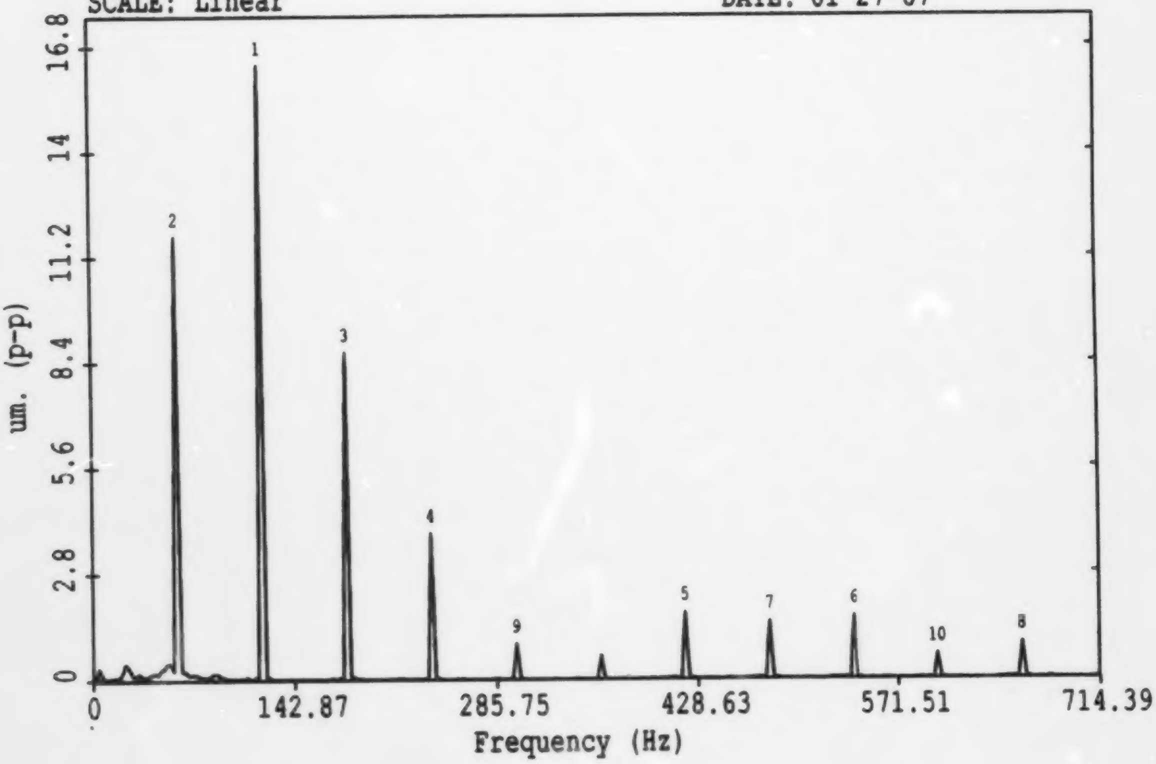


FIGURE 60

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	14.73
2	120.0	2.00	12.08
3	180.0	3.00	5.67
4	420.0	7.00	1.98
5	240.0	4.00	1.95
6	540.0	9.00	1.71
7	360.0	6.00	1.62
8	480.0	8.00	1.21
9	660.0	11.00	0.87
10	300.0	5.00	0.82

SCALE: Linear
DATE: 01-27-87

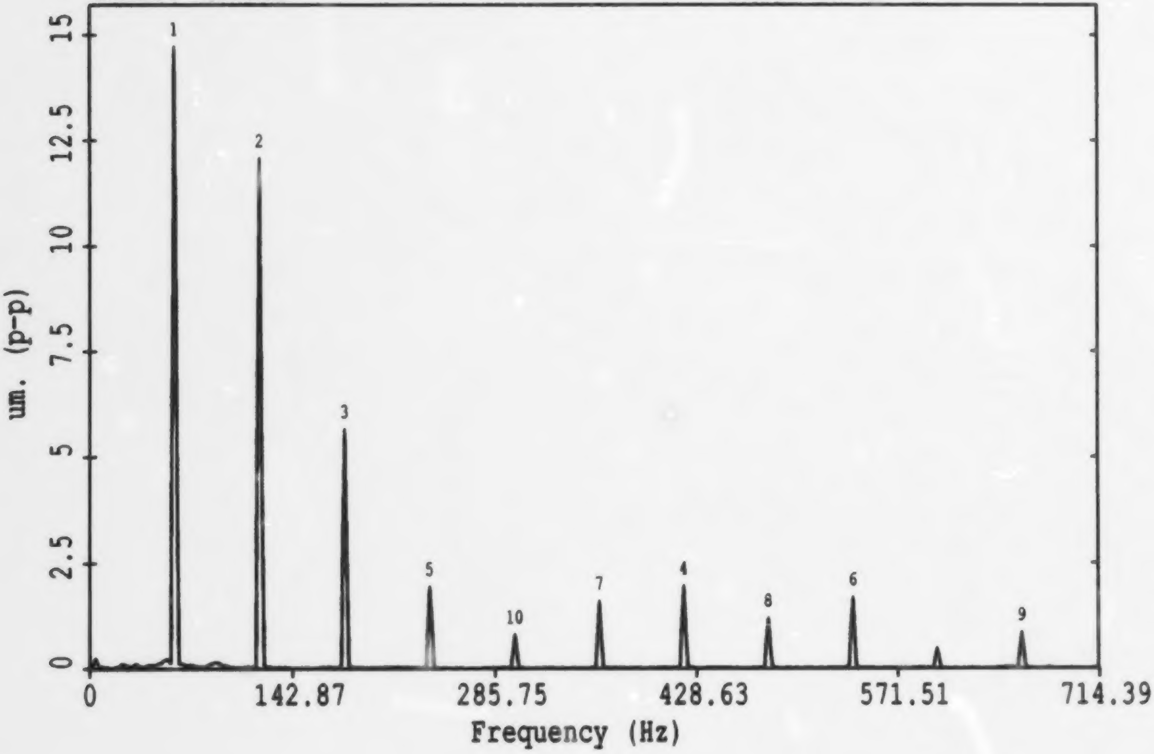


FIGURE 61

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	17.94
2	180.0	3.00	3.39
3	300.0	5.00	3.33
4	240.0	4.00	3.32
5	120.0	2.00	3.15
6	480.0	8.00	2.86
7	420.0	7.00	2.41
8	540.0	9.00	1.54
9	660.0	11.00	1.41
10	600.0	10.00	1.37

SCALE: Linear DATE: 01-27-87

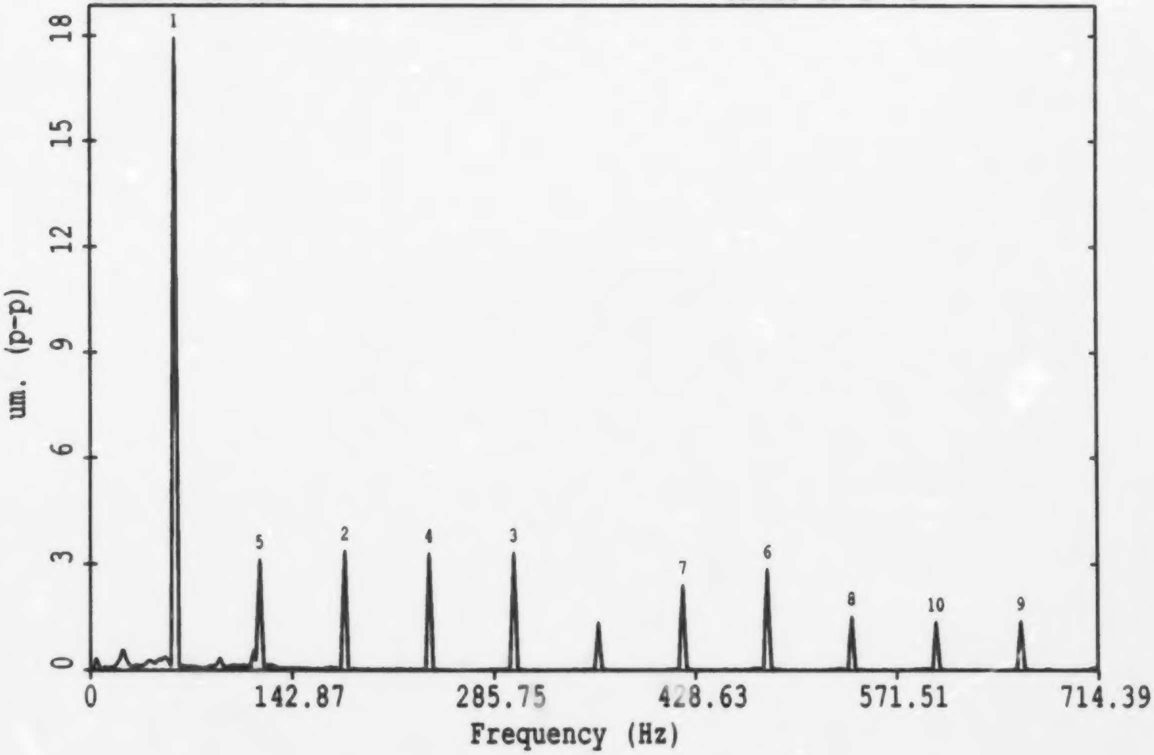


FIGURE 62

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	13.73
2	120.0	2.00	6.59
3	180.0	3.00	3.59
4	240.0	4.00	3.58
5	300.0	5.00	3.30
6	480.0	8.00	3.08
7	420.0	7.00	2.28
8	660.0	11.00	1.66
9	540.0	9.00	1.49
10	360.0	6.00	1.40

SCALE: Linear

DATE: 01-27-87

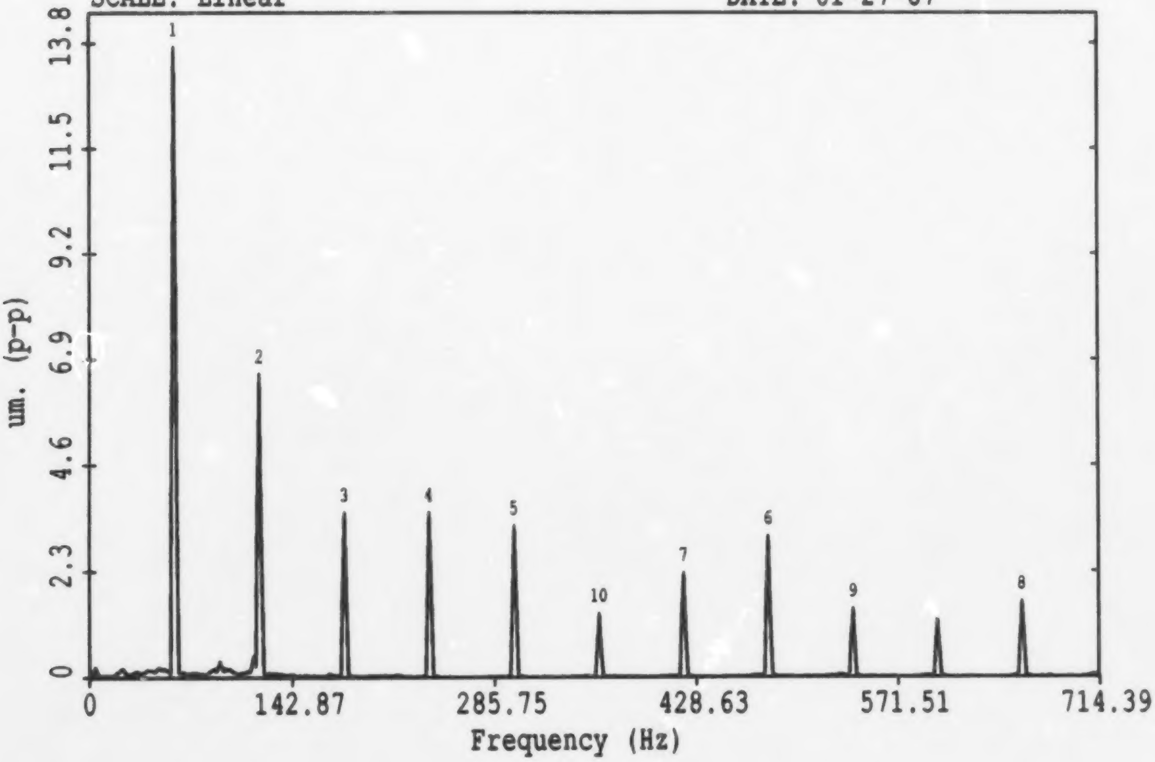


FIGURE 63

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	15.92
2	60.0	1.00	12.47
3	180.0	3.00	8.60
4	240.0	4.00	3.71
5	420.0	7.00	1.85
6	540.0	9.00	1.64
7	480.0	8.00	1.50
8	660.0	11.00	0.95
9	300.0	5.00	0.93
10	360.0	6.00	0.69

SCALE: Linear DATE: 01-27-87

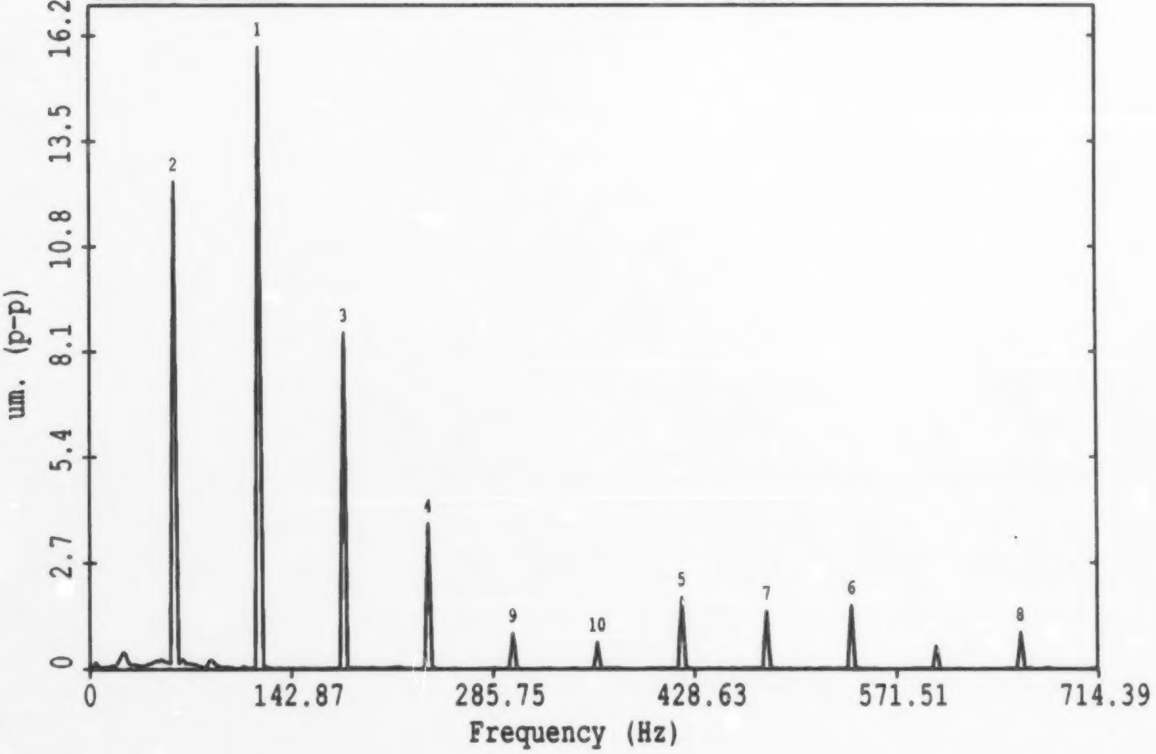


FIGURE 64

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	14.5[illegible]
2	120.0	2.00	11.77
3	180.0	3.00	5.33
4	420.0	7.00	1.92
5	240.0	4.00	1.85
6	360.0	6.00	1.72
7	540.0	9.00	1.69
8	480.0	8.00	1.17
9	660.0	11.00	0.90
10	300.0	5.00	0.90

SCALE: Linear

DATE: 01-27-87

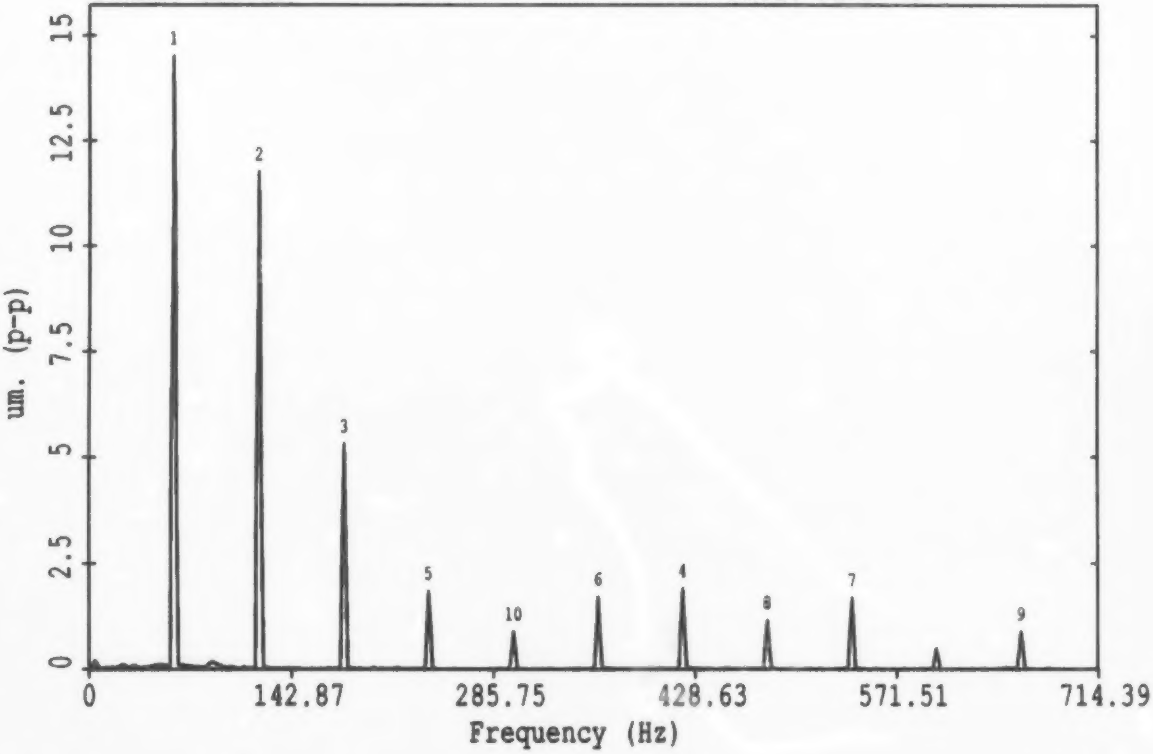


FIGURE 65

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	17.62
2	240.0	4.00	3.49
3	180.0	3.00	3.40
4	300.0	5.00	3.32
5	120.0	2.00	3.22
6	480.0	8.00	2.80
7	420.0	7.00	2.42
8	540.0	9.00	1.56
9	600.0	10.00	1.40
10	660.0	11.00	1.38

SCALE: Linear DATE: 01-27-87

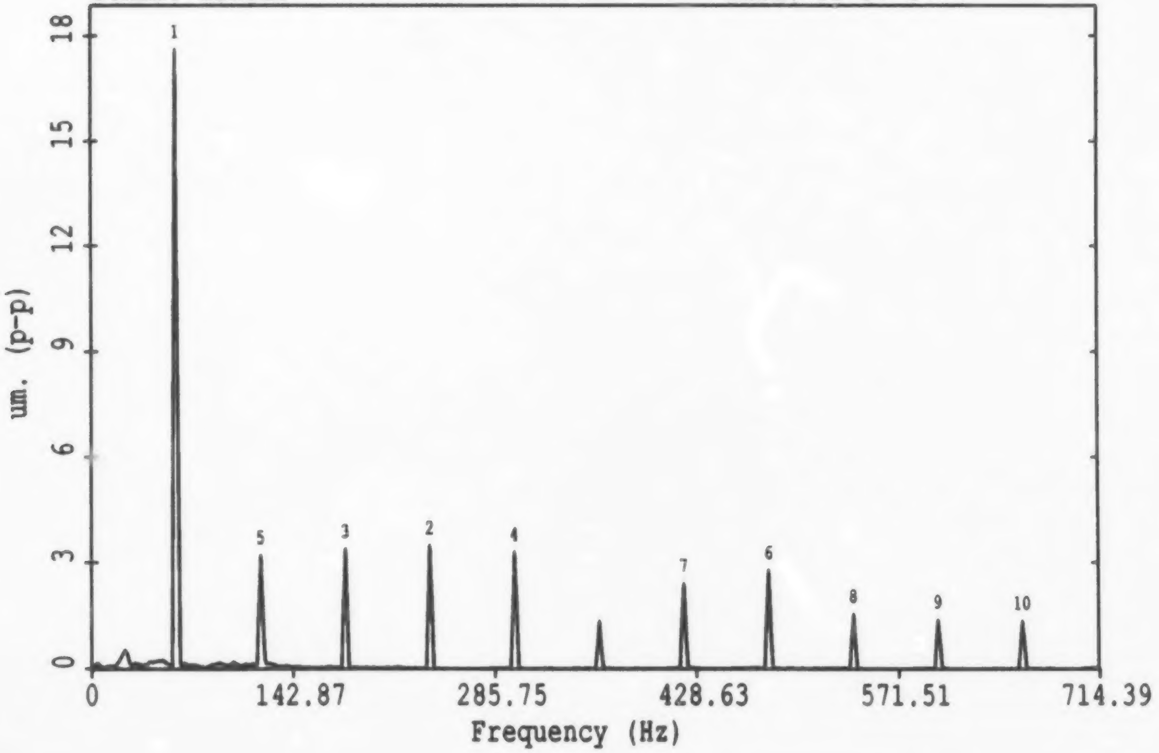


FIGURE 66

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	13.27
2	120.0	2.00	6.34
3	180.0	3.00	3.56
4	240.0	4.00	3.51
5	300.0	5.00	3.29
6	480.0	8.00	3.10
7	420.0	7.00	2.32
8	660.0	11.00	1.64
9	540.0	9.00	1.49
10	360.0	6.00	1.41

SCALE: Linear DATE: 01-27-87

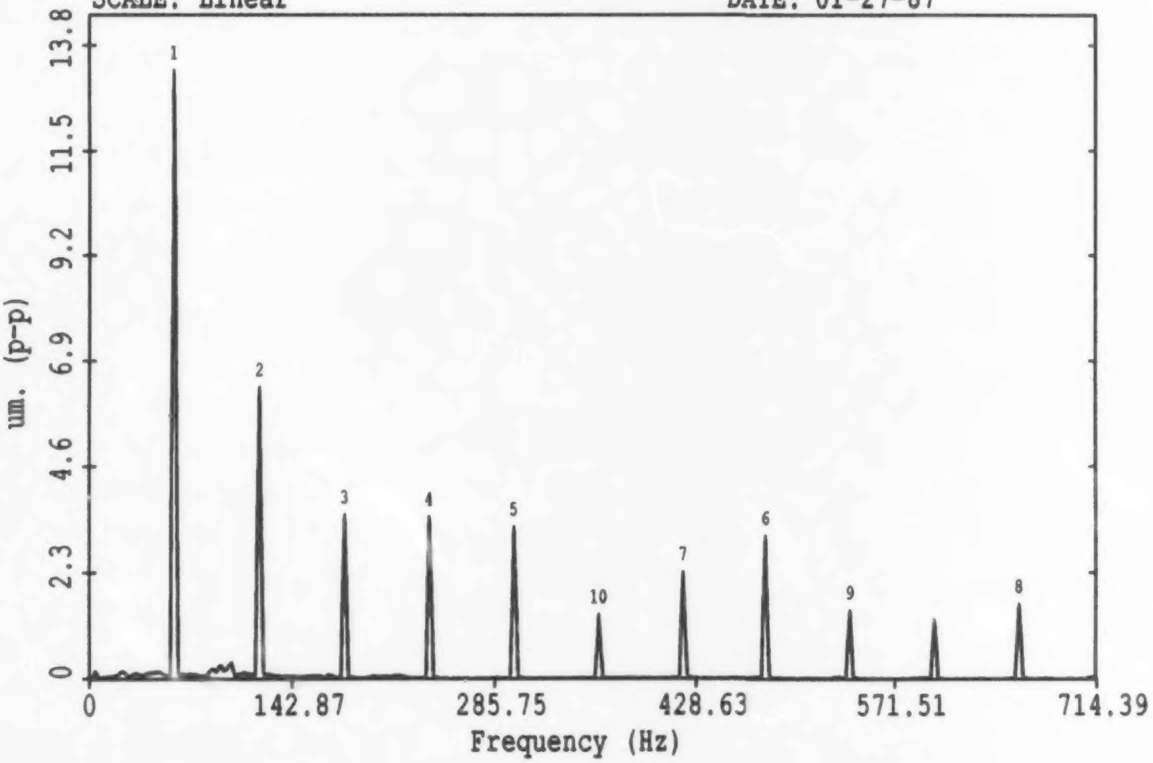
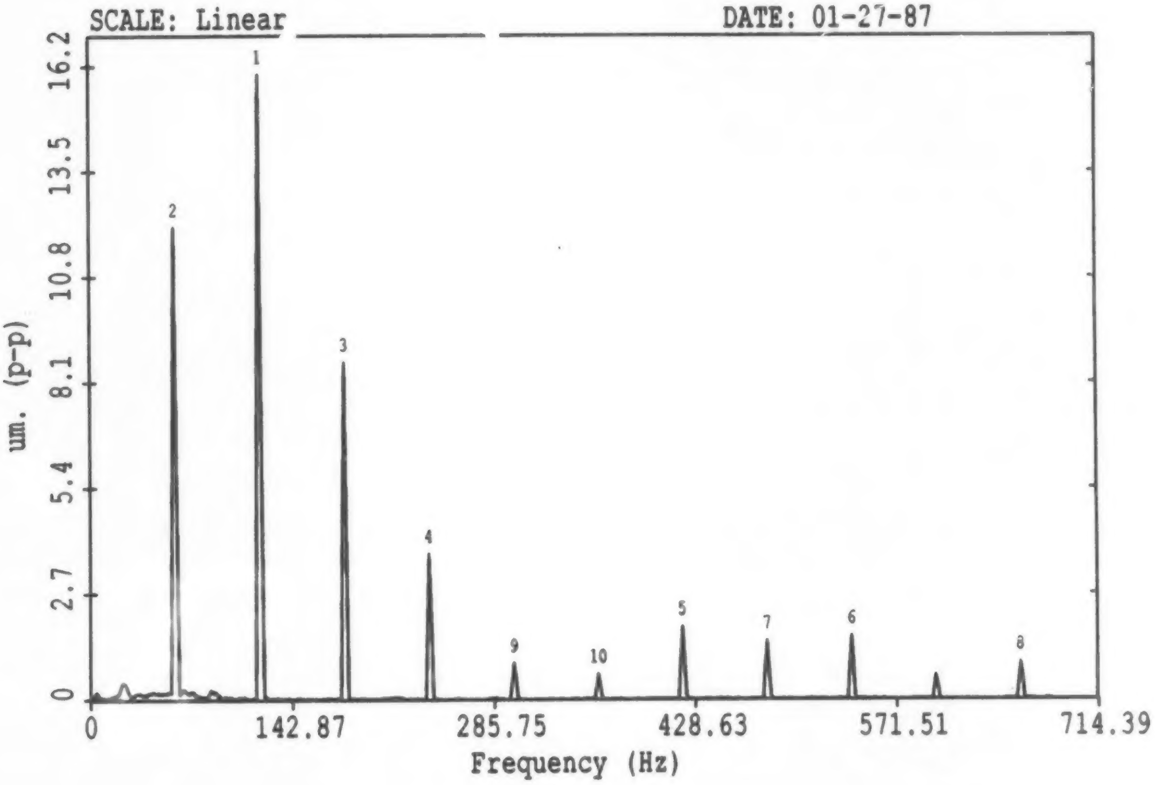


FIGURE 67

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	16.00
2	60.0	1.00	12.08
3	180.0	3.00	8.61
4	240.0	4.00	3.73
5	420.0	7.00	1.86
6	540.0	9.00	1.63
7	480.0	8.00	1.50
8	660.0	11.00	0.96
9	300.0	5.00	0.93
10	360.0	6.00	0.66



SCALE: Linear

DATE: 01-27-87

FIGURE 68

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	14.29
2	120.0	2.00	11.69
3	180.0	3.00	5.50
4	240.0	4.00	2.02
5	420.0	7.00	1.93
6	540.0	9.00	1.70
7	360.0	6.00	1.65
8	480.0	8.00	1.19
9	660.0	11.00	0.89
10	300.0	5.00	0.85

SCALE: Linear

DATE: 01-27-87

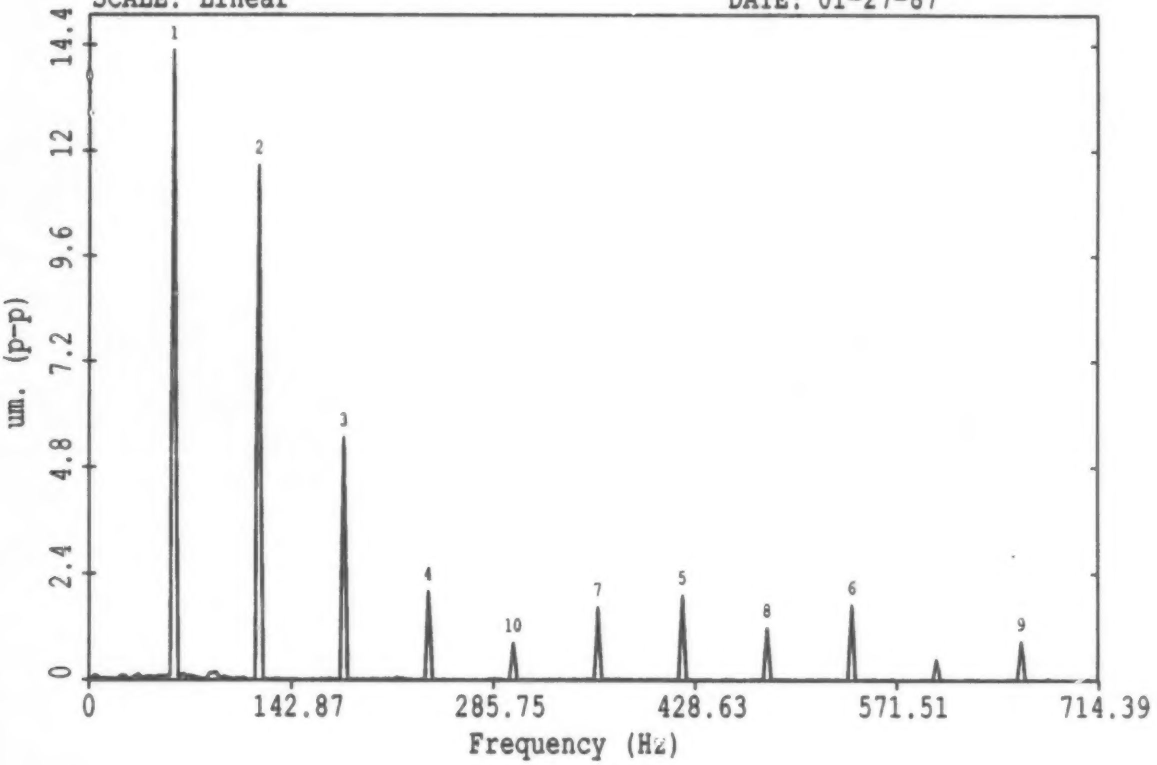


FIGURE 69

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	17.03
2	240.0	4.00	3.59
3	180.0	3.00	3.33
4	300.0	5.00	3.31
5	120.0	2.00	3.30
6	480.0	8.00	2.82
7	420.0	7.00	2.43
8	540.0	9.00	1.57
9	660.0	11.00	1.40
10	600.0	10.00	1.39

SCALE: Linear

DATE: 01-27-87

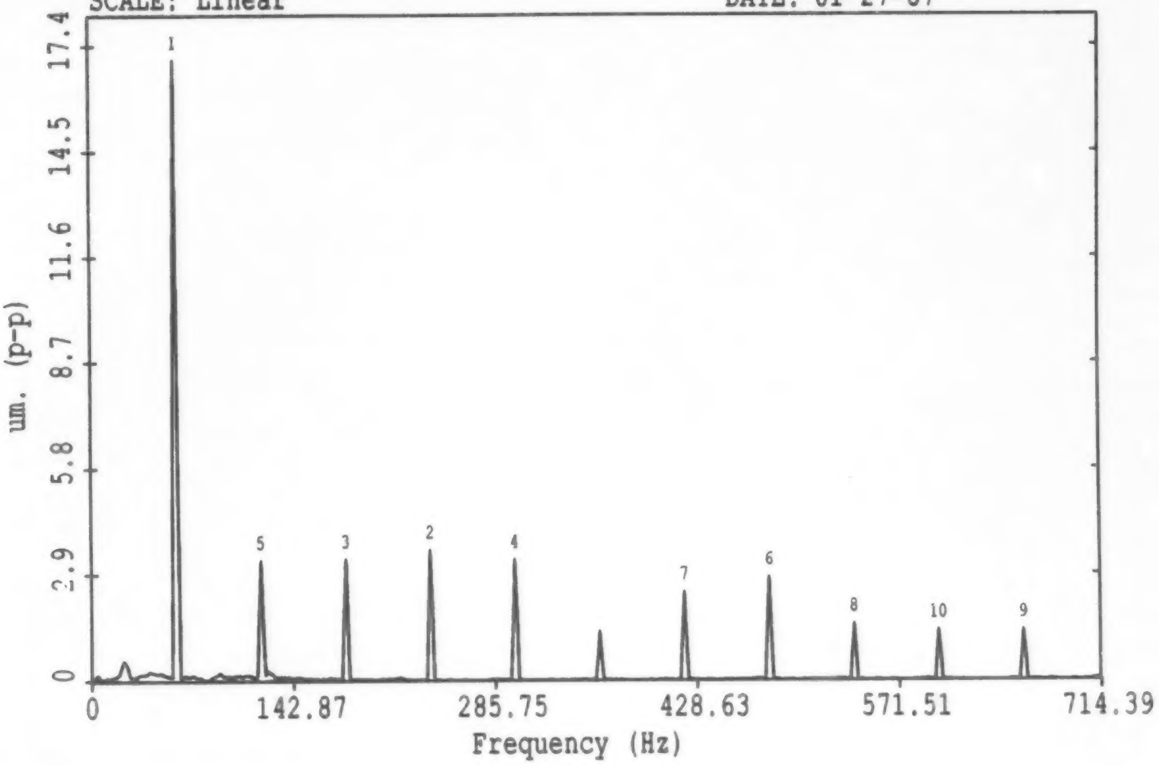


FIGURE 70

Darlington GS Standby Generator #3 AC Generator

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	13.24
2	120.0	2.00	6.39
3	180.0	3.00	3.55
4	240.0	4.00	3.46
5	300.0	5.00	3.27
6	480.0	8.00	3.10
7	420.0	7.00	2.32
8	660.0	11.00	1.65
9	540.0	9.00	1.49
10	360.0	6.00	1.42

SCALE: Linear DATE: 01-27-87

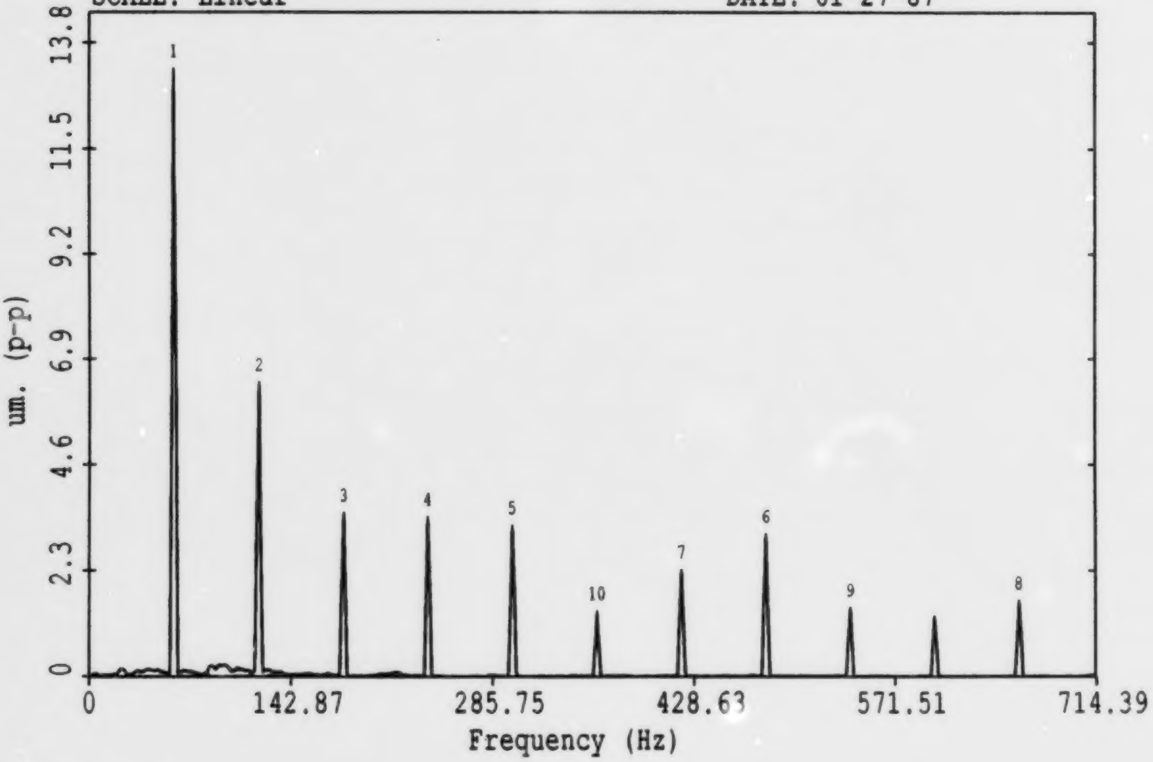


FIGURE 71

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	12.42
2	120.0	2.00	9.22
3	16.7	0.28	6.47
4	39.1	0.65	5.47
5	180.0	3.00	4.94
6	240.0	4.00	4.15
7	34.9	0.58	3.66
8	360.0	6.00	3.45
9	44.6	0.74	3.29
10	29.3	0.49	3.21

SCALE: Linear

DATE: 01-27-87

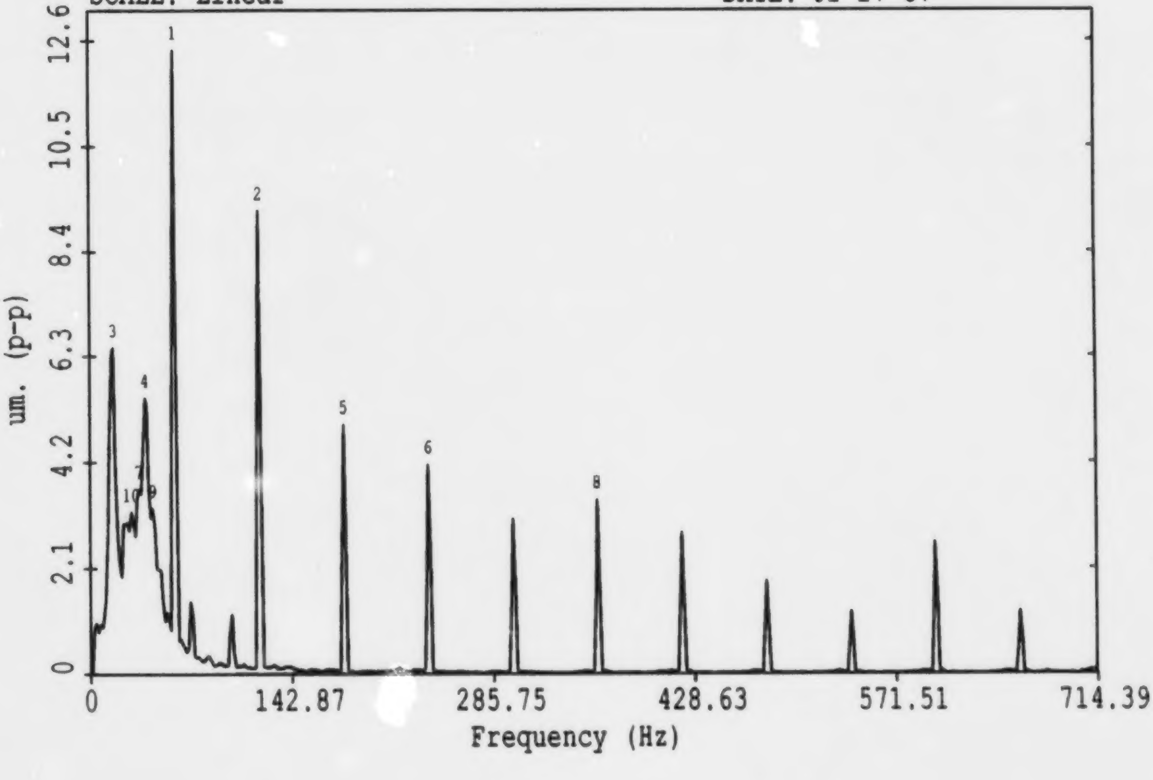


FIGURE 72

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	19.27
2	16.7	0.28	10.83
3	120.0	2.00	9.59
4	39.1	0.65	6.12
5	29.3	0.49	4.82
6	180.0	3.00	4.53
7	240.0	4.00	4.39
8	23.7	0.40	4.35
9	34.9	0.58	4.31
10	26.5	0.44	4.25

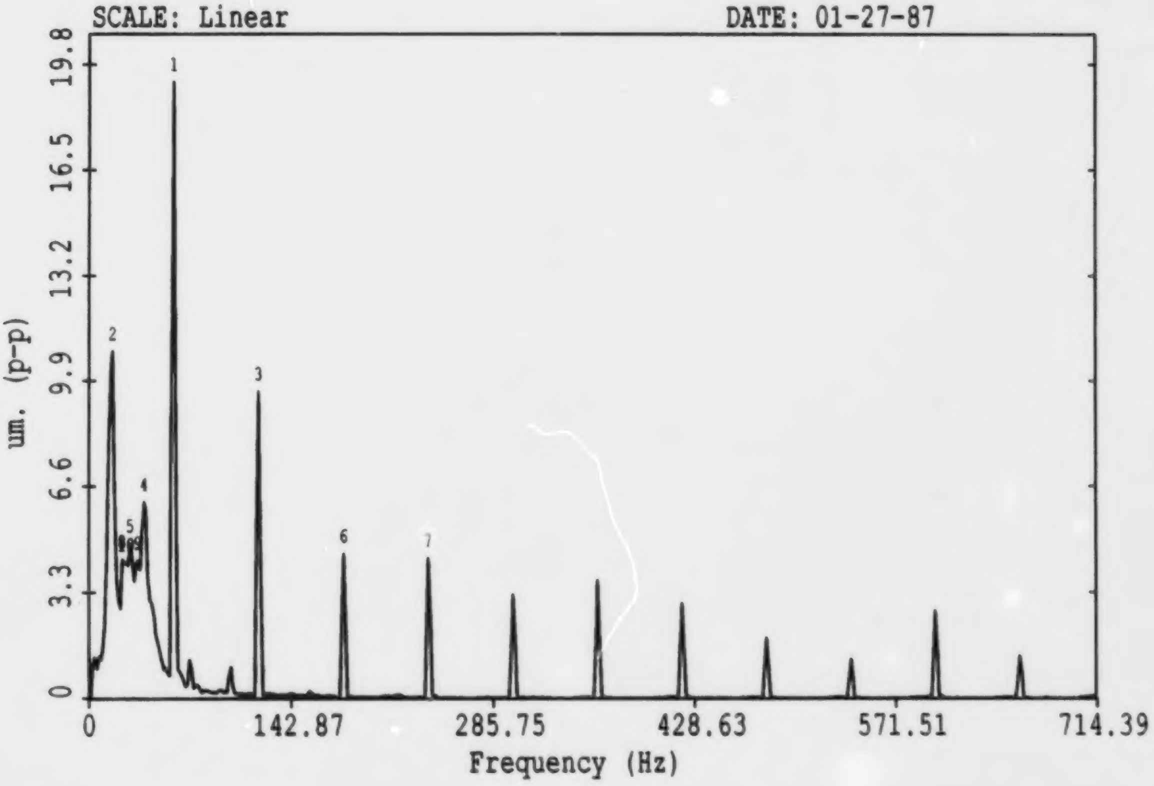


FIGURE 73

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	6.38
2	19.5	0.33	3.33
3	180.0	3.00	1.57
4	60.0	1.00	1.50
5	23.7	0.40	1.10
6	240.0	4.00	1.00
7	480.0	8.00	0.99
8	40.5	0.67	0.97
9	420.0	7.00	0.95
10	30.7	0.51	0.85

SCALE: Linear

DATE: 01-27-87

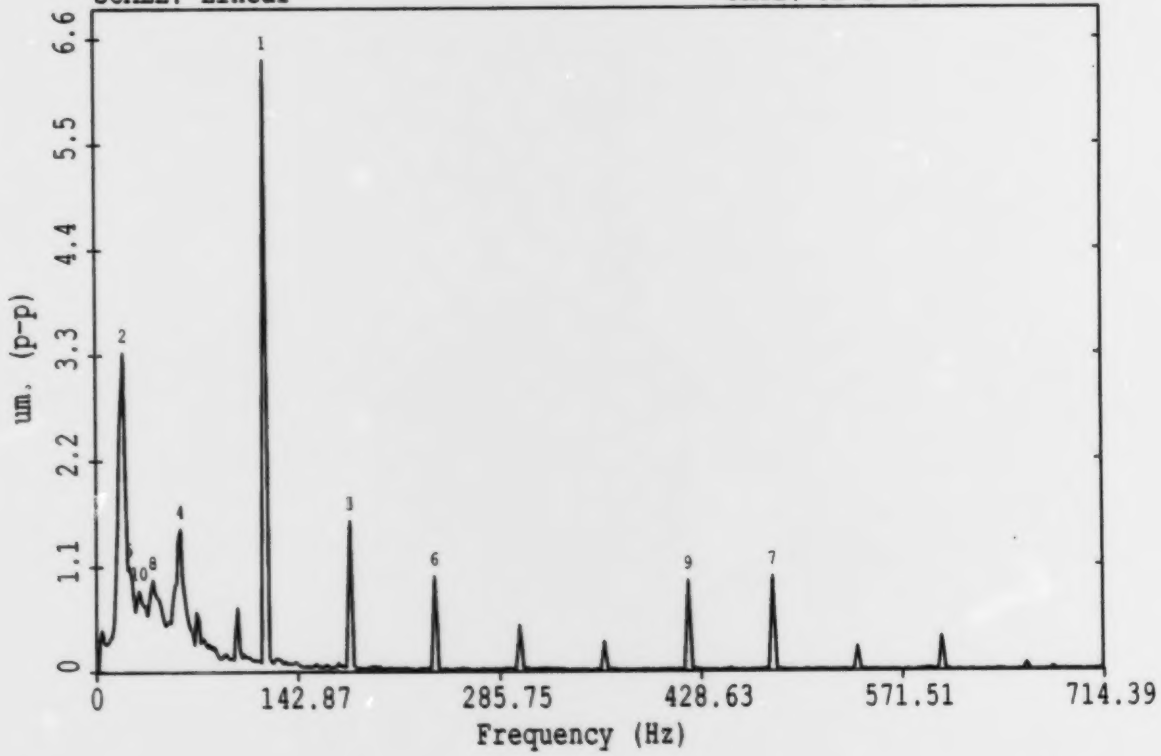


FIGURE 74

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 0 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	11.20
2	120.0	2.00	7.30
3	60.0	1.00	6.55
4	23.7	0.40	3.76
5	30.7	0.51	2.70
6	40.5	0.67	2.33
7	44.6	0.74	2.24
8	51.6	0.86	1.85
9	180.0	3.00	1.74
10	4.2	0.07	1.68

SCALE: Linear DATE: 01-27-87

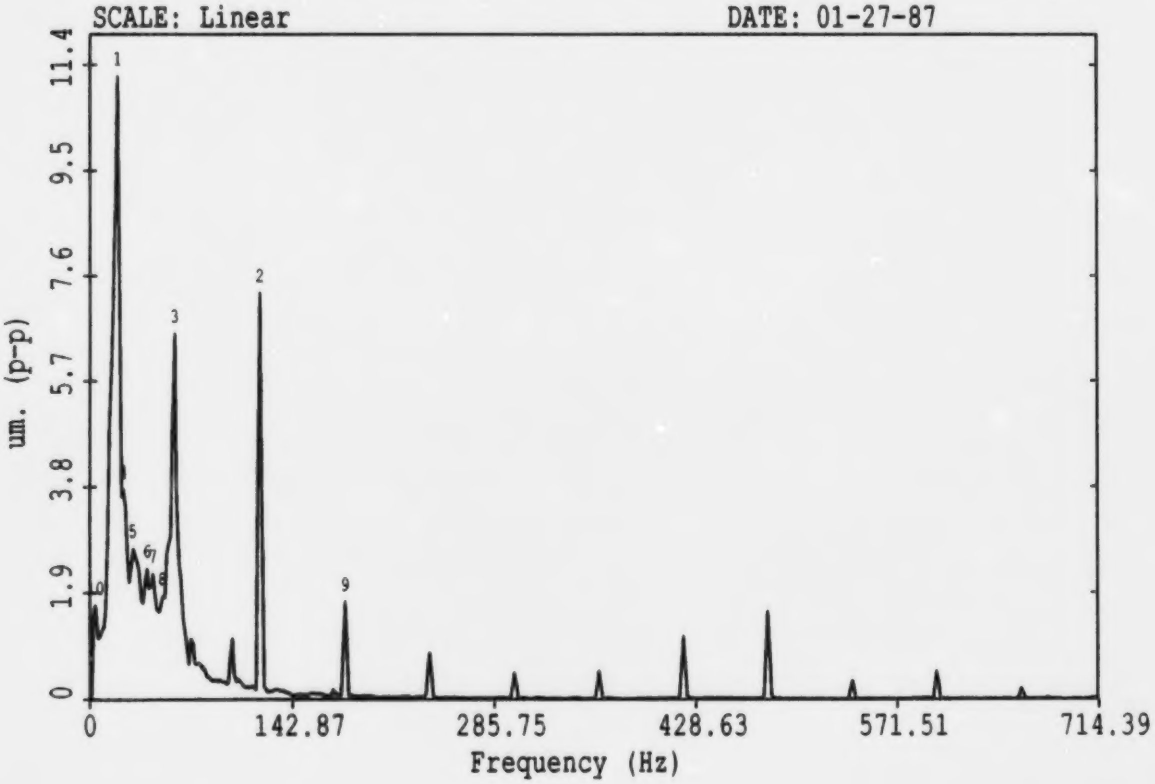


FIGURE 75

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	21.30
2	120.0	2.00	9.46
3	15.3	0.26	8.41
4	180.0	3.00	4.92
5	40.5	0.67	4.73
6	27.9	0.47	4.42
7	30.7	0.51	4.38
8	240.0	4.00	4.28
9	51.6	0.86	3.71
10	360.0	6.00	3.40

SCALE: Linear DATE: 01-27-87

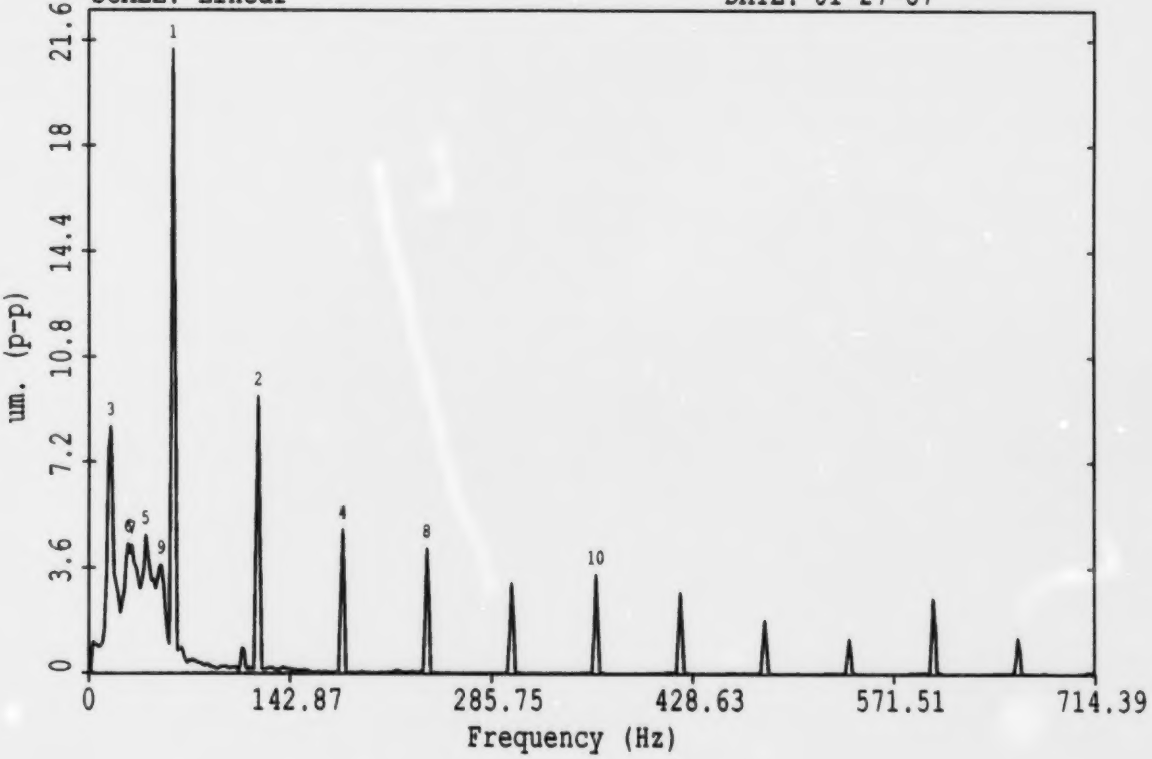


FIGURE 76

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	21.56
2	120.0	2.00	9.44
3	15.3	0.26	6.74
4	180.0	3.00	4.76
5	240.0	4.00	4.37
6	360.0	6.00	3.72
7	30.7	0.51	3.58
8	27.9	0.47	3.57
9	300.0	5.00	3.36
10	40.5	0.67	3.27

SCALE: Linear DATE: 01-27-87

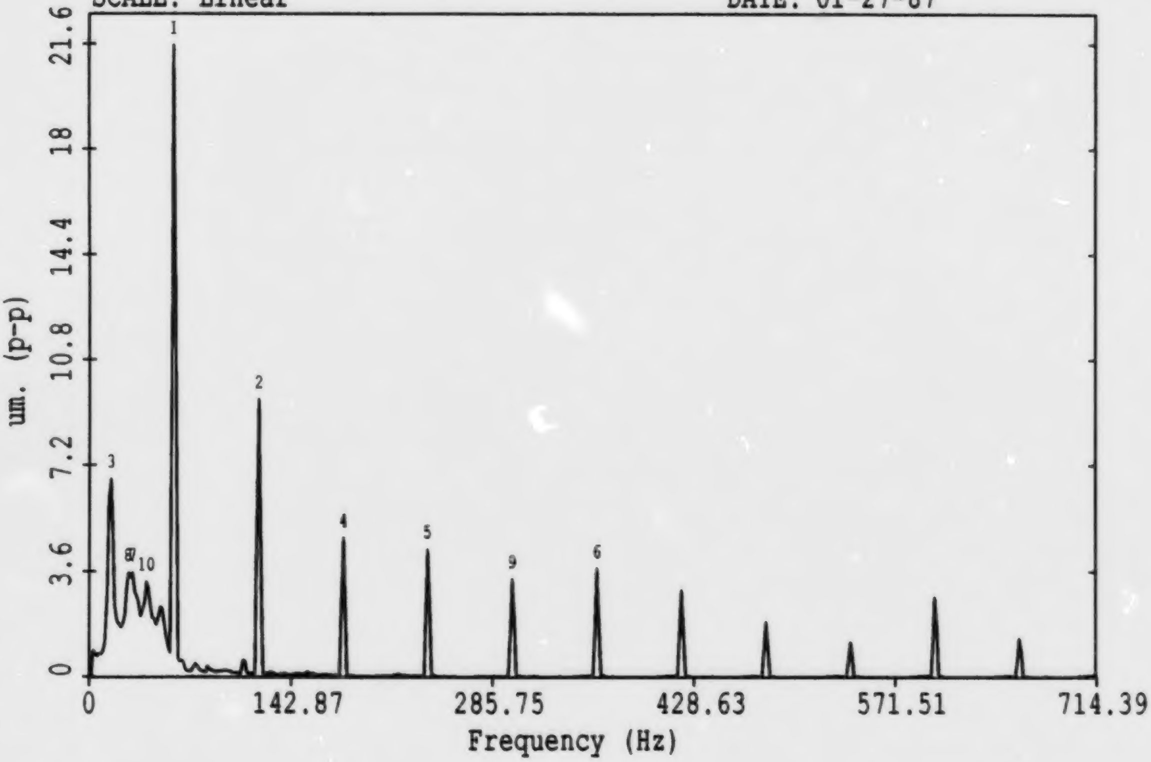


FIGURE 77

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	6.26
2	19.5	0.33	2.92
3	60.0	1.00	2.78
4	180.0	3.00	1.70
5	240.0	4.00	1.04
6	480.0	8.00	0.99
7	23.7	0.40	0.96
8	44.6	0.74	0.93
9	30.7	0.51	0.91
10	40.5	0.67	0.86

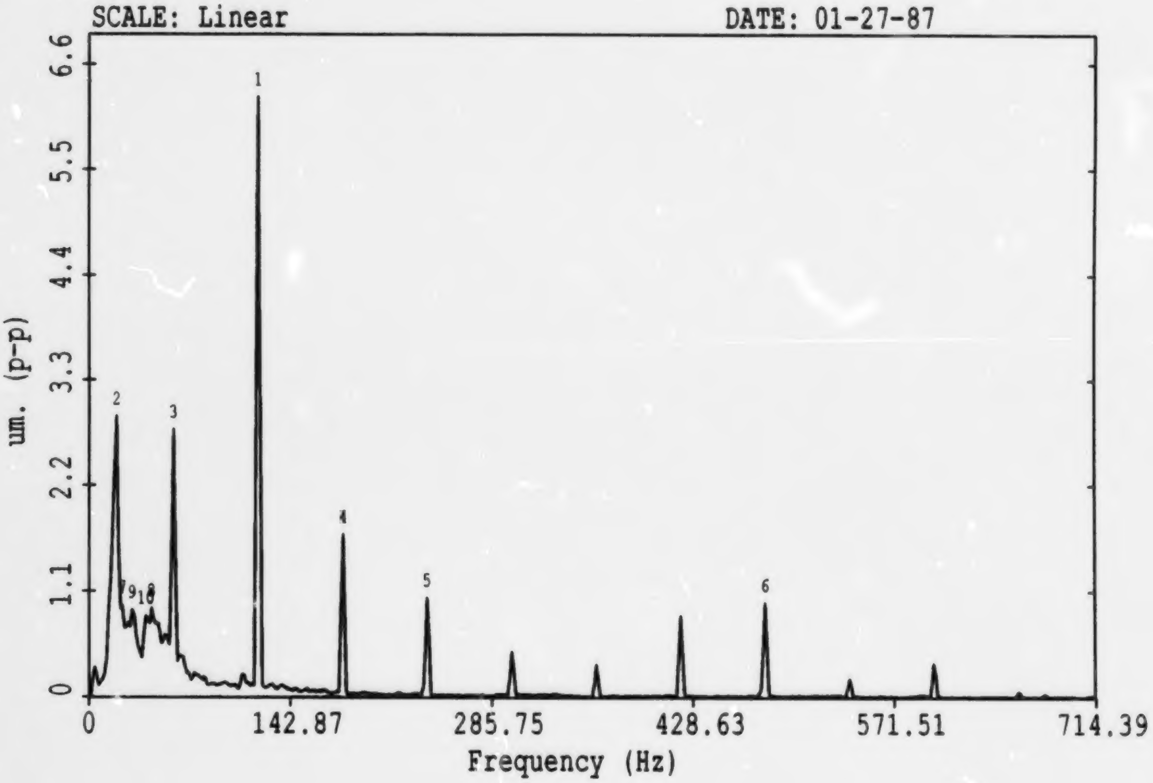


FIGURE 78

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 7 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	11.51
2	14.0	0.23	8.14
3	60.0	1.00	7.83
4	120.0	2.00	6.92
5	23.7	0.40	3.80
6	30.7	0.51	3.05
7	26.5	0.44	2.87
8	48.8	0.81	2.54
9	44.6	0.74	2.53
10	54.4	0.91	2.39

SCALE: Linear

DATE: 01-27-87

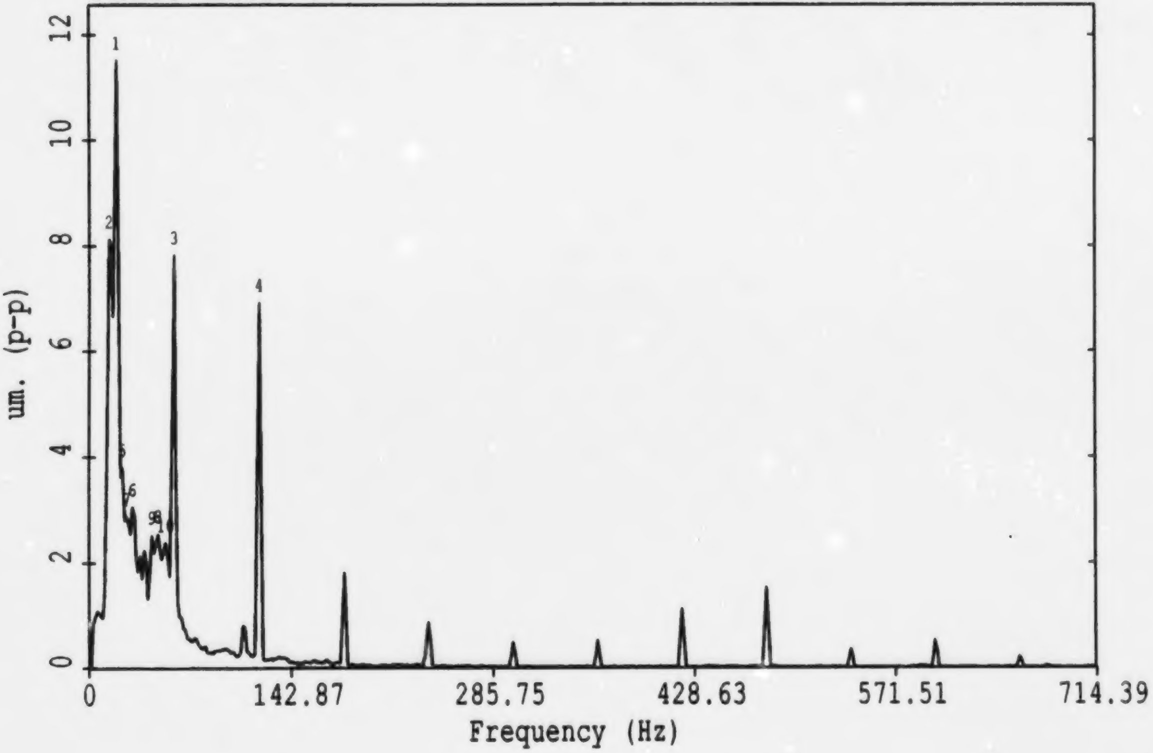


FIGURE 79

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	25.85
2	120.0	2.00	9.61
3	15.3	0.26	6.36
4	180.0	3.00	4.97
5	40.5	0.67	4.68
6	25.1	0.42	4.43
7	29.3	0.49	4.36
8	240.0	4.00	4.32
9	43.3	0.72	4.16
10	53.0	0.88	3.87

SCALE: Linear

DATE: 01-27-87

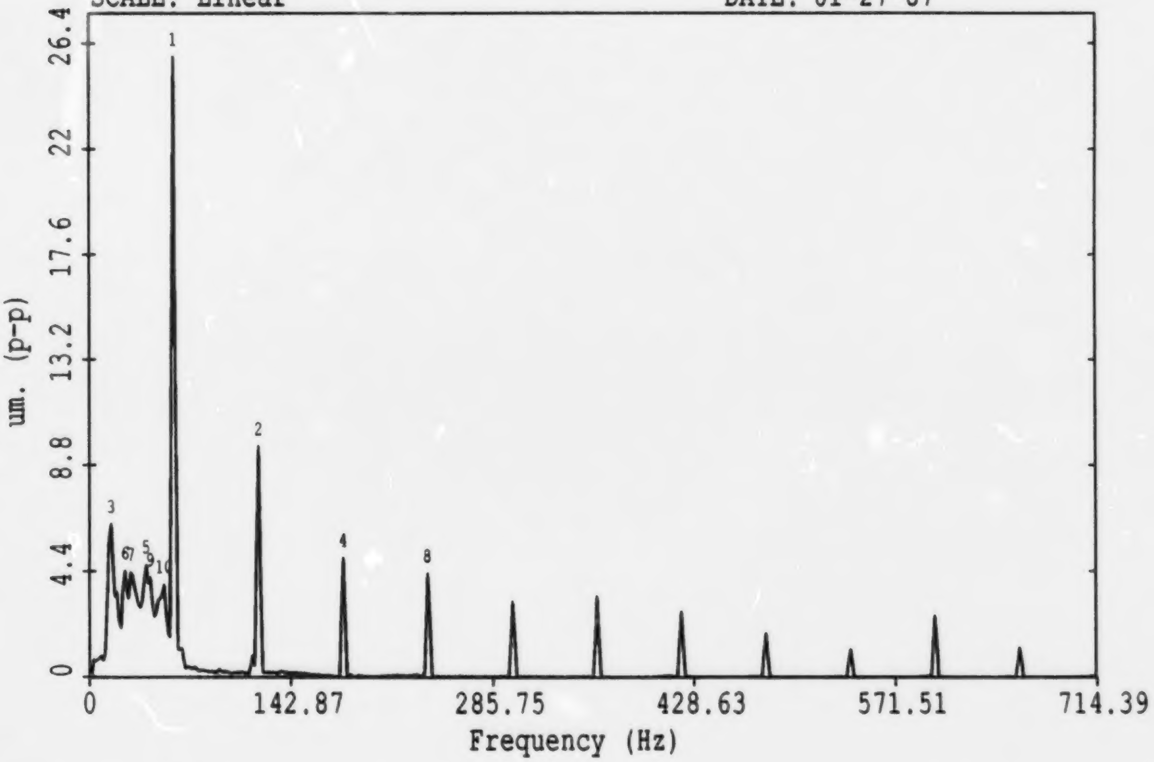


FIGURE 80

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	21.32
2	120.0	2.00	9.36
3	180.0	3.00	4.83
4	240.0	4.00	4.34
5	360.0	6.00	3.73
6	15.3	0.26	3.53
7	300.0	5.00	3.42
8	420.0	7.00	2.96
9	600.0	10.00	2.77
10	29.3	0.49	2.58

SCALE: Linear

DATE: 01-27-87

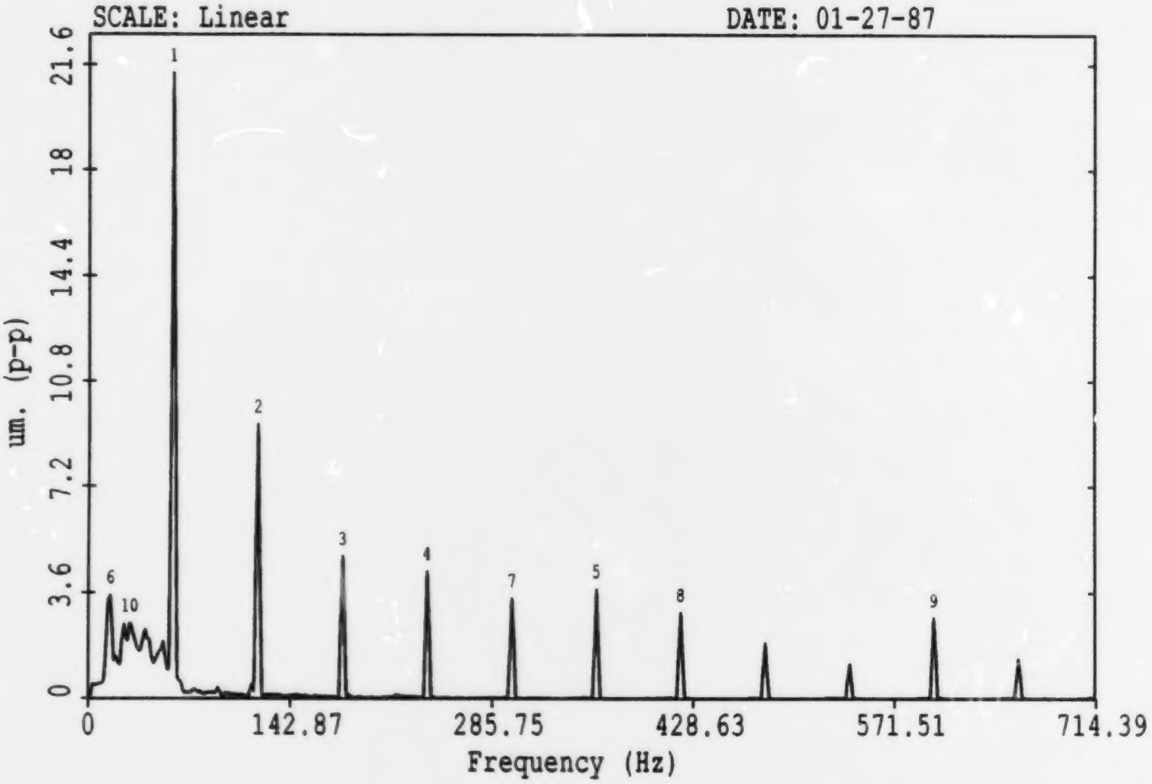


FIGURE 81

Darlington GS Standby Generator #3 Power Turbine

SIGNAL   : Outboard Brg. Shaft Displacement X-Axis
SPEED   : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	6.33
2	60.0	1.00	3.02
3	19.5	0.33	2.87
4	180.0	3.00	1.93
5	23.7	0.40	1.13
6	240.0	4.00	1.08
7	480.0	8.00	1.01
8	29.3	0.49	0.85
9	41.9	0.70	0.83
10	420.0	7.00	0.79

SCALE: Linear   DATE: 01-27-87

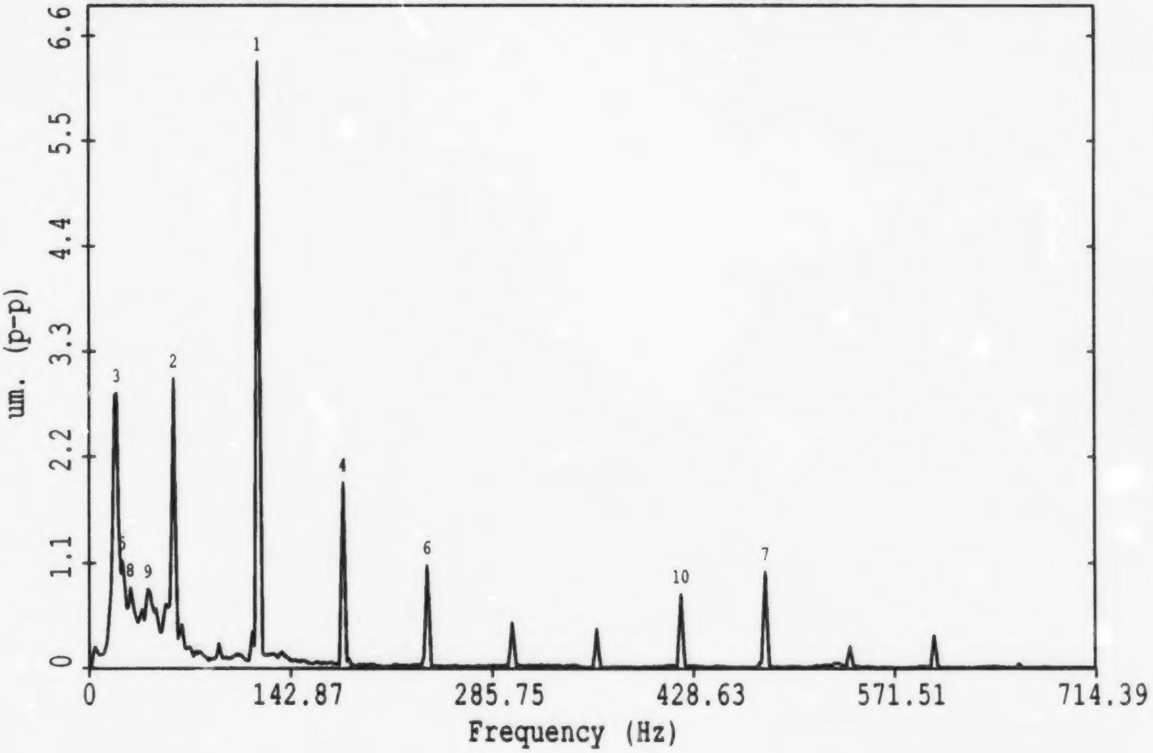


FIGURE 82

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 13 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	13.61
2	60.0	1.00	6.79
3	120.0	2.00	6.71
4	23.7	0.40	5.31
5	29.3	0.49	3.13
6	47.4	0.79	2.56
7	37.7	0.63	2.52
8	43.3	0.72	1.94
9	180.0	3.00	1.94
10	480.0	8.00	1.54

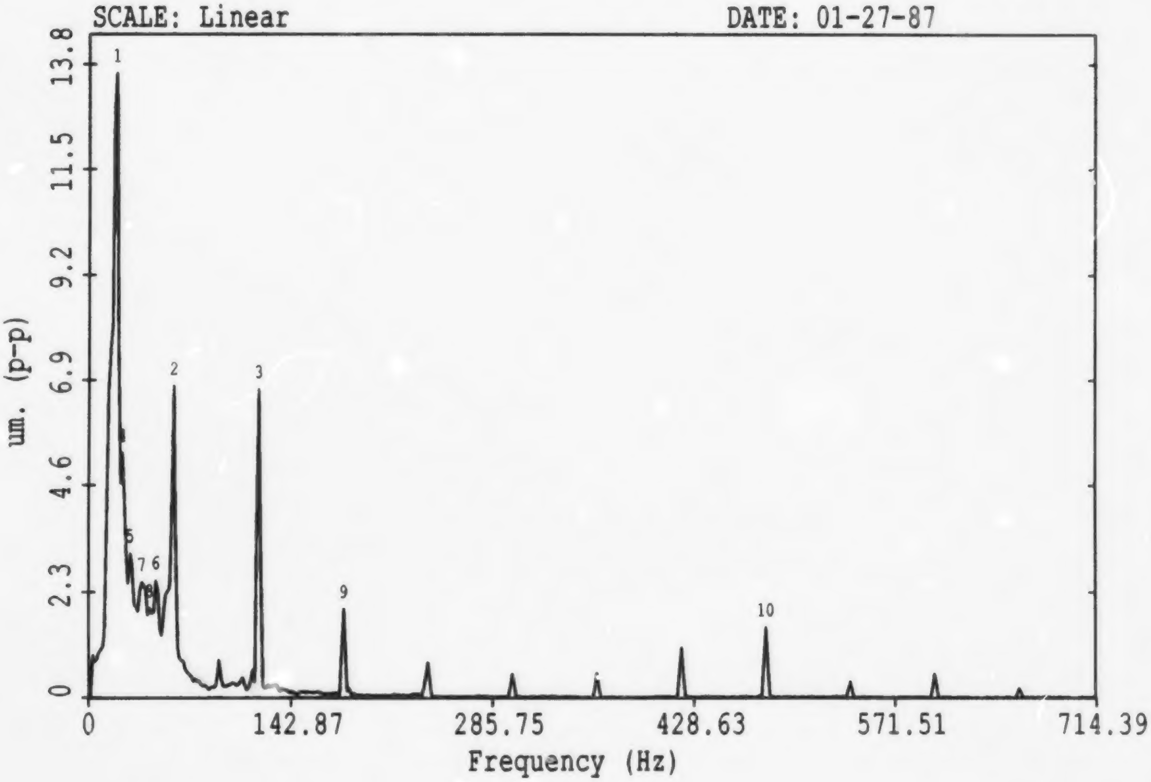


FIGURE 83

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	29.43
2	120.0	2.00	9.92
3	180.0	3.00	4.98
4	26.5	0.44	4.52
5	240.0	4.00	4.33
6	14.0	0.23	4.30
7	19.5	0.33	3.61
8	41.9	0.70	3.49
9	36.3	0.60	3.49
10	360.0	6.00	3.36

SCALE: Linear

DATE: 01-27-87

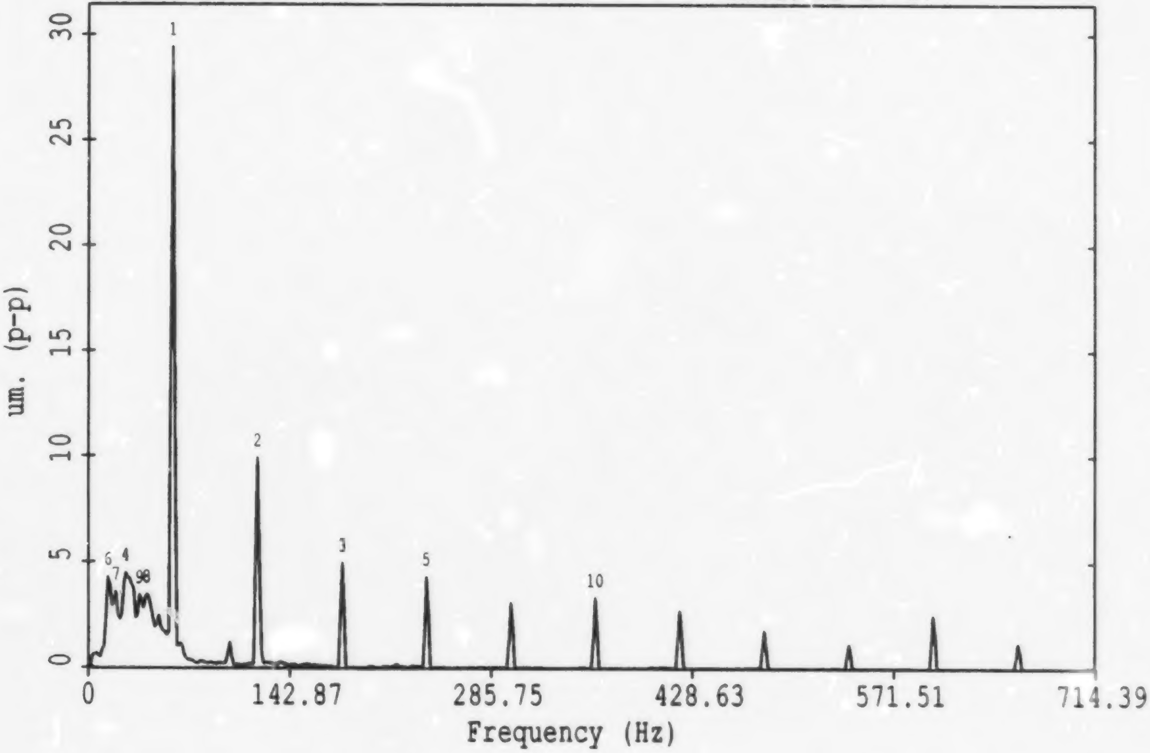


FIGURE 84

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	21.09
2	120.0	2.00	9.20
3	180.0	3.00	4.86
4	240.0	4.00	4.26
5	360.0	6.00	3.73
6	300.0	5.00	3.30
7	420.0	7.00	2.87
8	600.0	10.00	2.72
9	26.5	0.44	2.28
10	14.0	0.23	2.26

SCALE: Linear DATE: 01-27-87

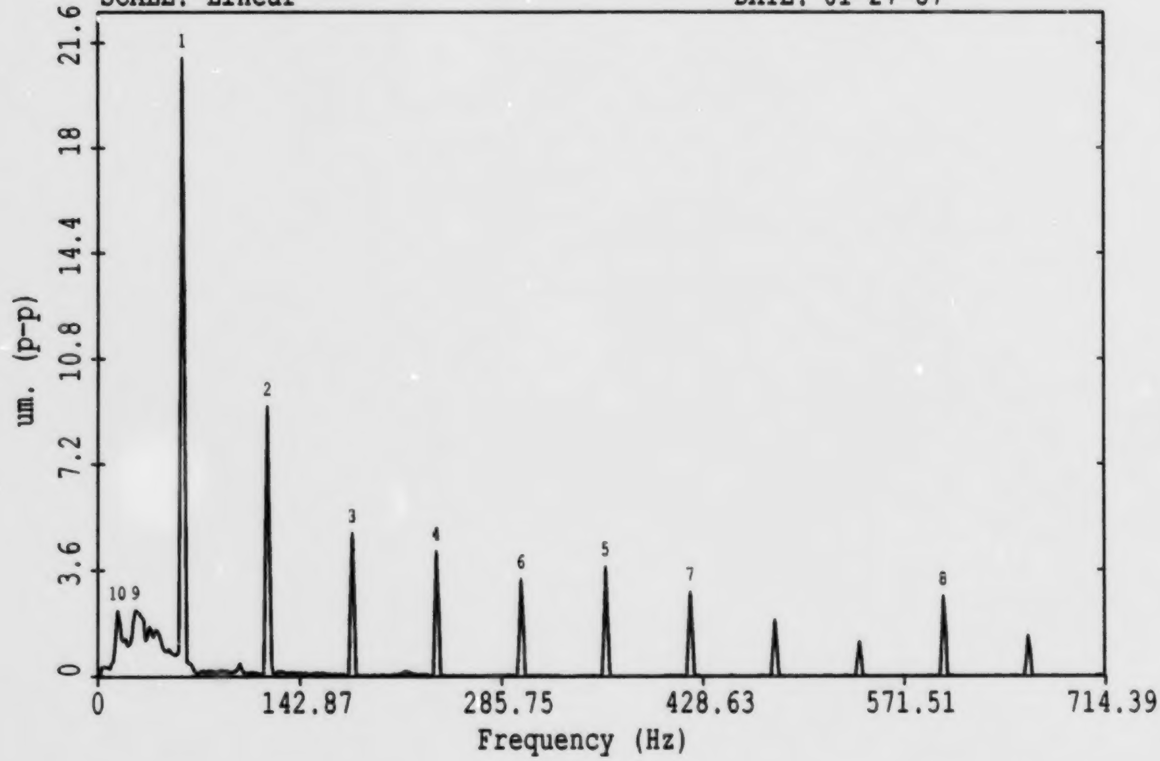
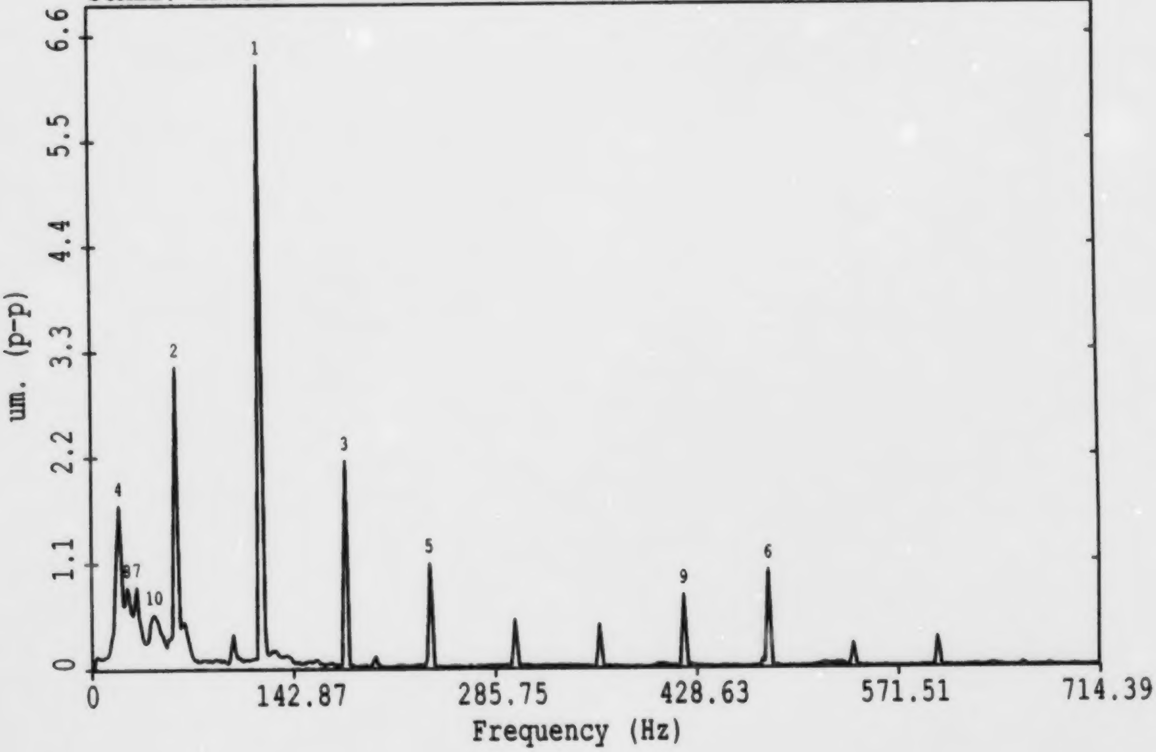


FIGURE 85

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	6.30
2	60.0	1.00	3.15
3	180.0	3.00	2.16
4	19.5	0.33	1.71
5	240.0	4.00	1.09
6	480.0	8.00	1.02
7	32.1	0.53	0.86
8	25.1	0.42	0.85
9	420.0	7.00	0.76
10	44.6	0.74	0.58



SCALE: Linear

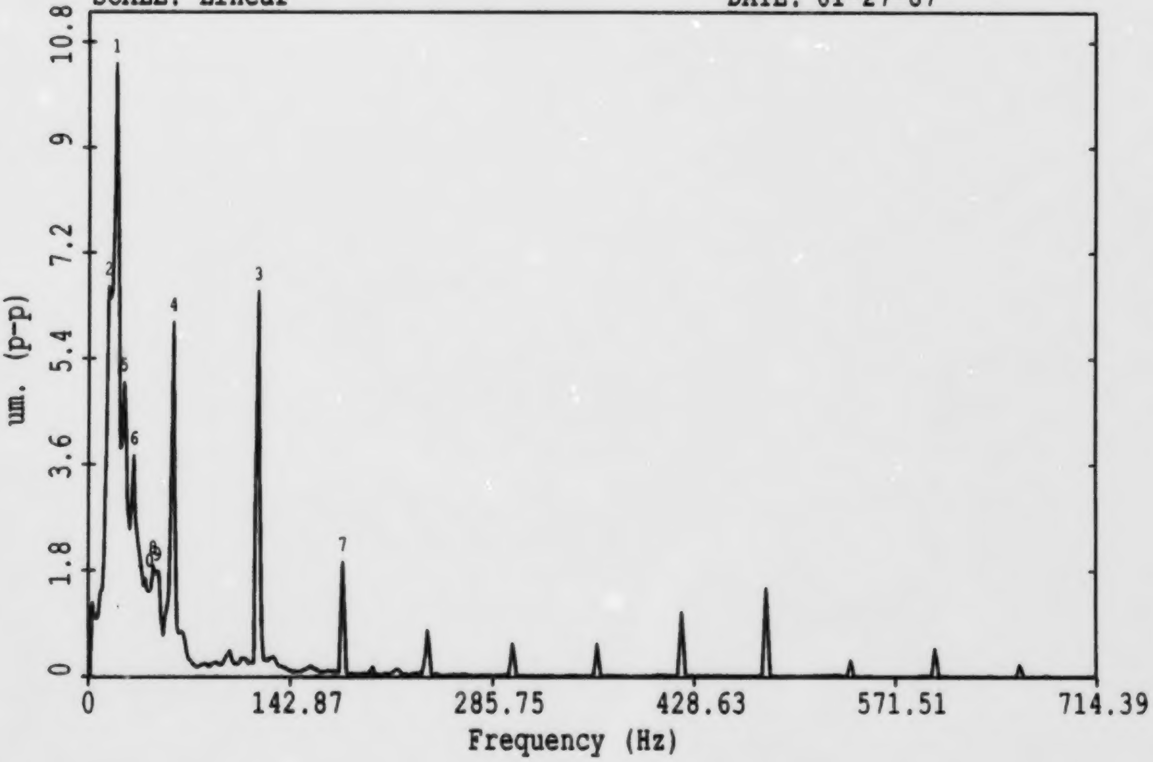
DATE: 01-27-87

FIGURE 86

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 20 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	19.5	0.33	10.44
2	14.0	0.23	6.64
3	120.0	2.00	6.55
4	60.0	1.00	6.03
5	25.1	0.42	4.99
6	32.1	0.53	3.75
7	180.0	3.00	1.95
8	46.0	0.77	1.89
9	48.8	0.81	1.78
10	40.5	0.67	1.68


SCALE: Linear

DATE: 01-27-87

FIGURE 87

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	31.55
2	120.0	2.00	9.96
3	180.0	3.00	5.06
4	29.3	0.49	5.03
5	240.0	4.00	4.35
6	40.5	0.67	3.78
7	37.7	0.63	3.76
8	43.3	0.72	3.55
9	15.3	0.26	3.53
10	360.0	6.00	3.38

SCALE: Linear

DATE: 01-27-87

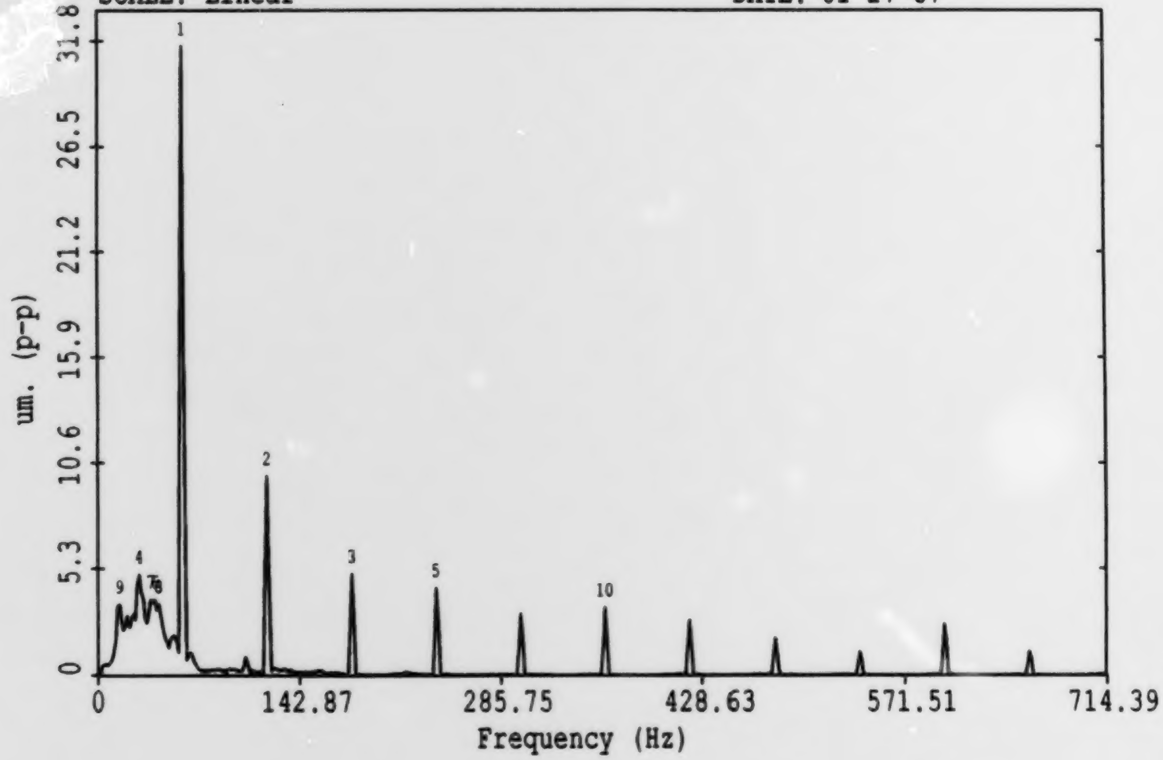


FIGURE 88

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Inboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	60.0	1.00	21.67
2	120.0	2.00	9.29
3	180.0	3.00	4.93
4	240.0	4.00	4.28
5	360.0	6.00	3.75
6	300.0	5.00	3.40
7	420.0	7.00	2.92
8	600.0	10.00	2.72
9	29.3	0.49	2.38
10	480.0	8.00	1.93

SCALE: Linear   DATE: 01-27-87

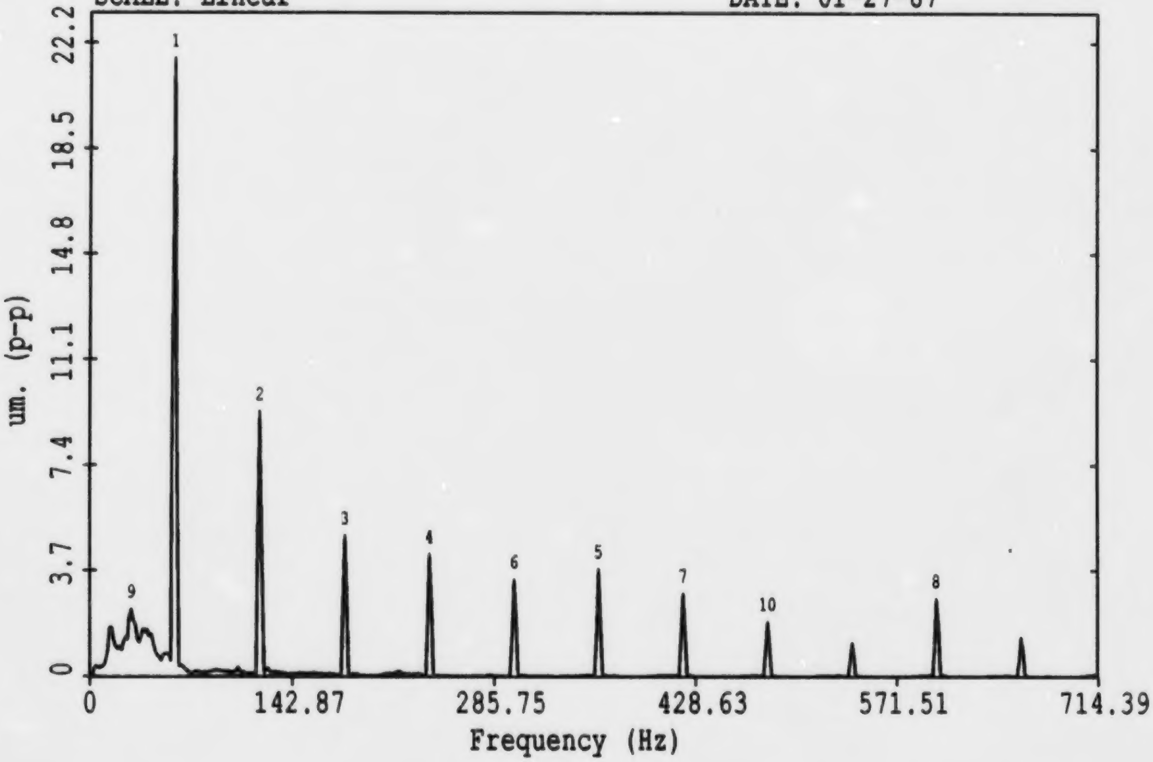


FIGURE 89

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement X-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	120.0	2.00	6.40
2	60.0	1.00	3.60
3	180.0	3.00	2.25
4	20.9	0.35	1.25
5	240.0	4.00	1.05
6	480.0	8.00	1.01
7	30.7	0.51	0.75
8	420.0	7.00	0.74
9	300.0	5.00	0.63
10	65.6	1.09	0.59

SCALE: Linear

DATE: 01-27-87

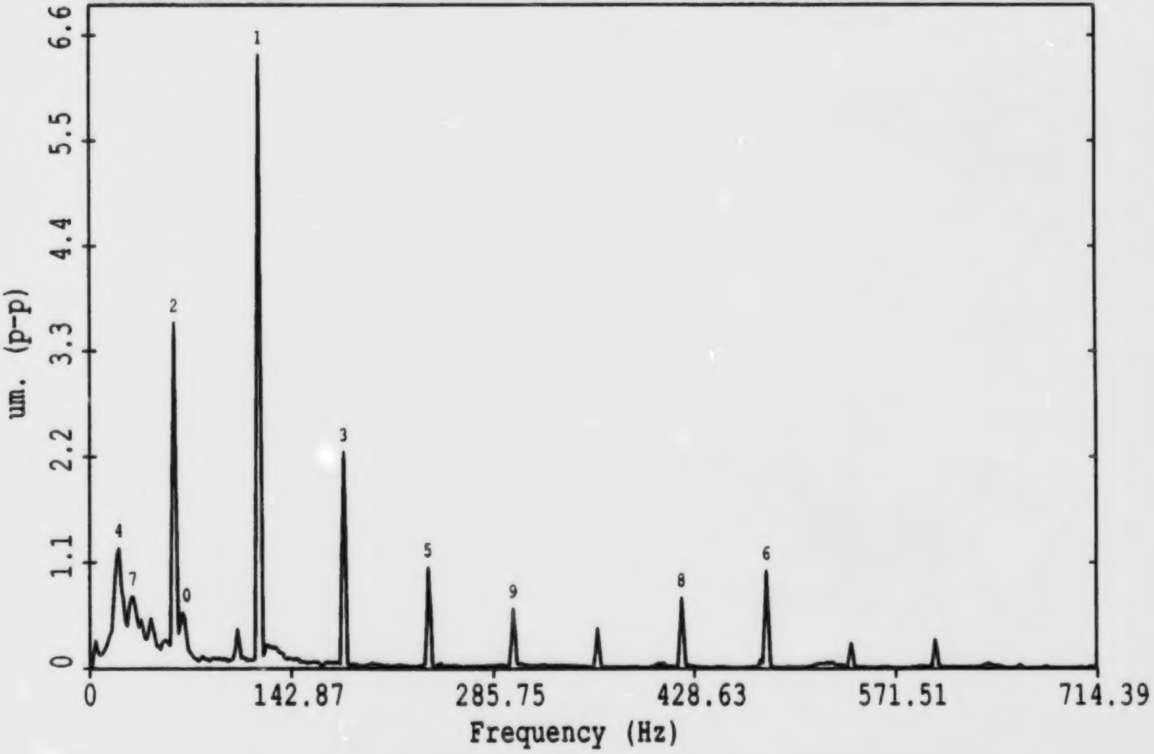


FIGURE 90

Darlington GS Standby Generator #3 Power Turbine

SIGNAL : Outboard Brg. Shaft Displacement Y-Axis
SPEED : 3600 r.p.m.
PROCESS CONDITION : Load 26 MW

PEAK NO.	FREQUENCY	ORDER	AMPLITUDE
1	20.9	0.35	8.29
2	120.0	2.00	6.59
3	15.3	0.26	6.30
4	60.0	1.00	5.88
5	29.3	0.49	3.89
6	37.7	0.63	3.04
7	180.0	3.00	2.01
8	480.0	8.00	1.52
9	44.6	0.74	1.36
10	5.6	0.09	1.23

SCALE: Linear DATE: 01-27-87

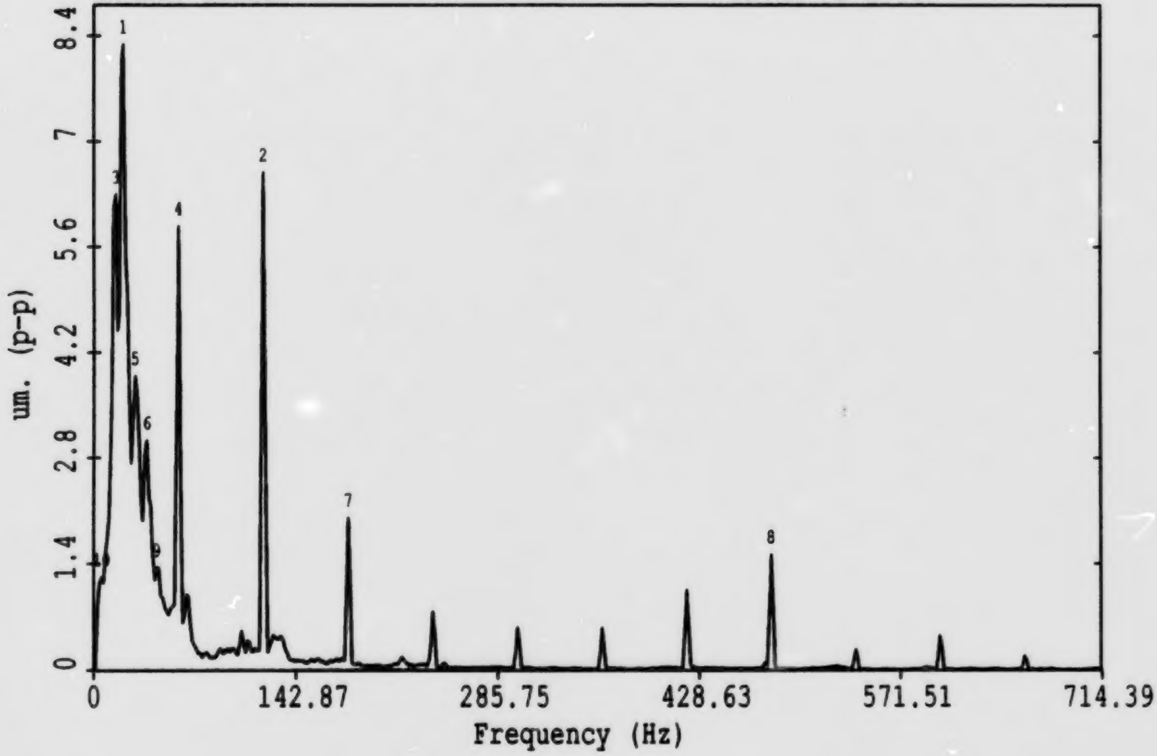


FIGURE 91

Darlington GS Standby Generator #3 - Cold Start
AC Generator Outboard Brg. Casing Velocity X-Axis
BODE PLOT : Run-up
Ch # 2
Date : 27-Jan-1987
Order : 1.00

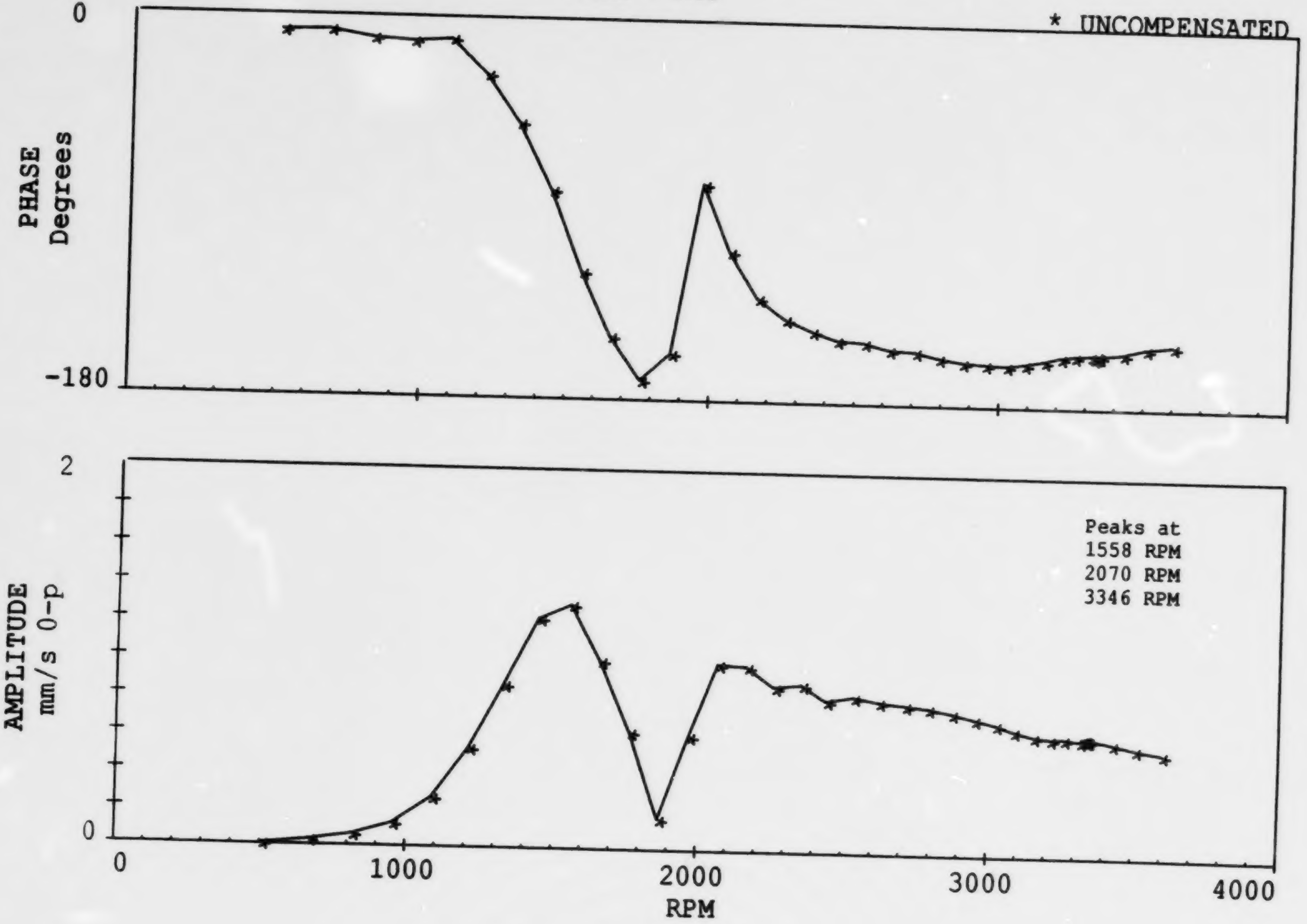


FIGURE 92

Darlington GS Standby Generator #3 - Cold Start
AC Generator Outboard Brg. Casing Velocity Y-Axis

BODE PLOT : Run-up
Ch # 1

Date : 27-Jan-1987
Order : 1.00

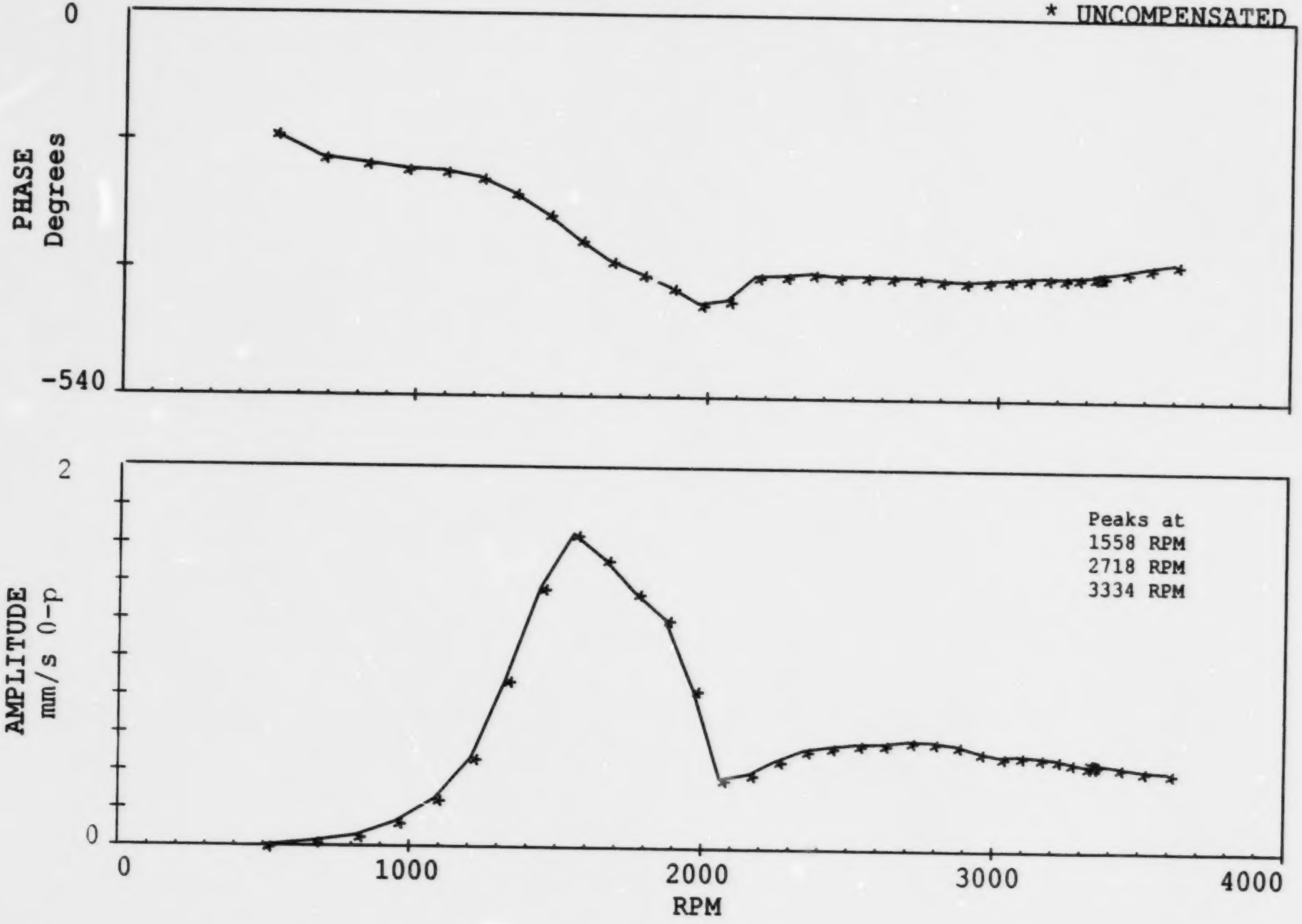


FIGURE 93

Darlington GS Standby Generator #3 - Cold Start
AC Generator Outboard Brg. Casing Velocity Axial

BODE PLOT : Run-up
Ch # 3

Date : 27-Jan-1987
Order : 1.00

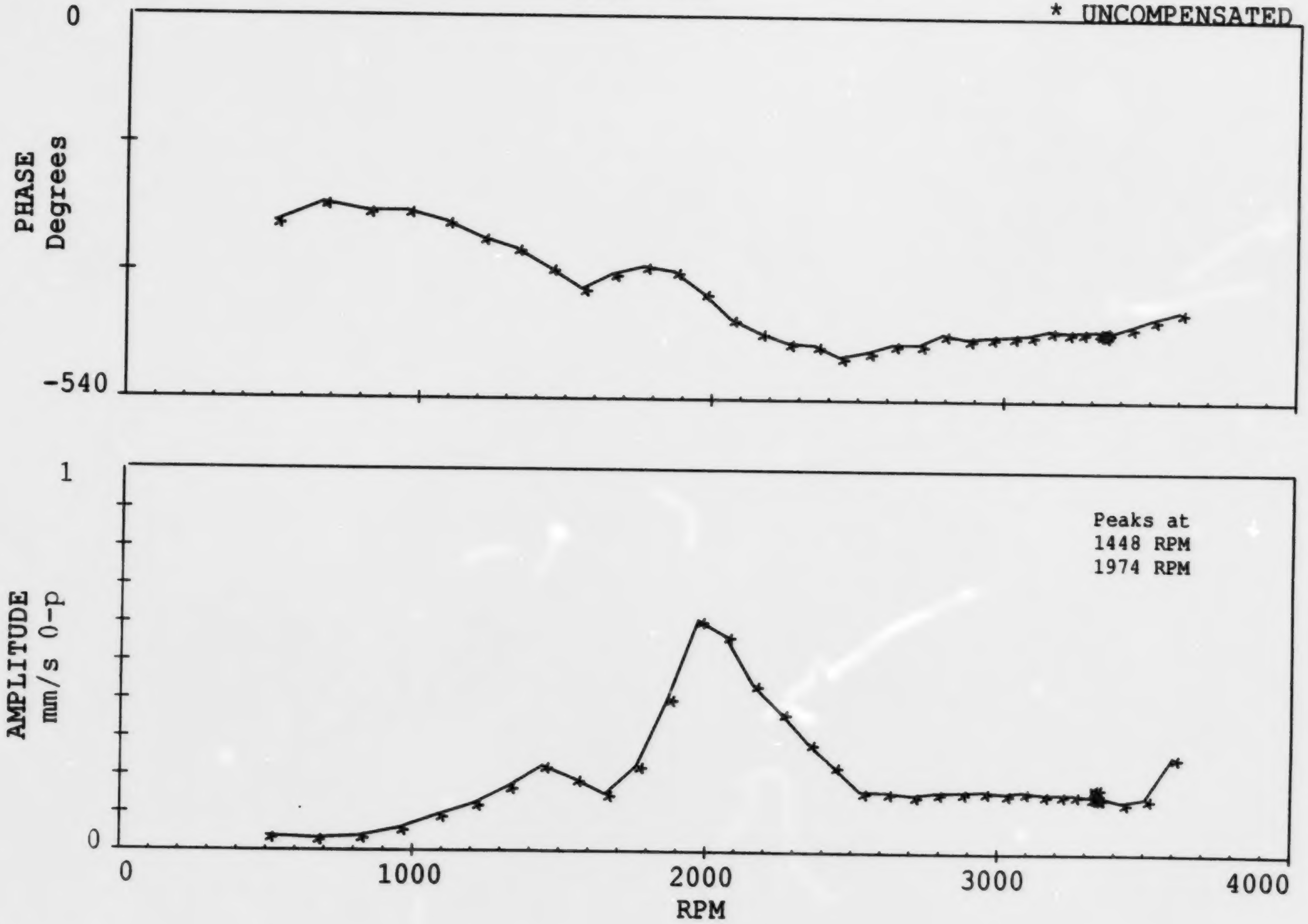


FIGURE 94

Darlington GS Standby Generator #3 - Cold Start
AC Generator Inboard Brg. Casing Velocity X-Axis

BODE PLOT : Run-up
Ch # 5

Date : 27-Jan-1987
Order : 1.00

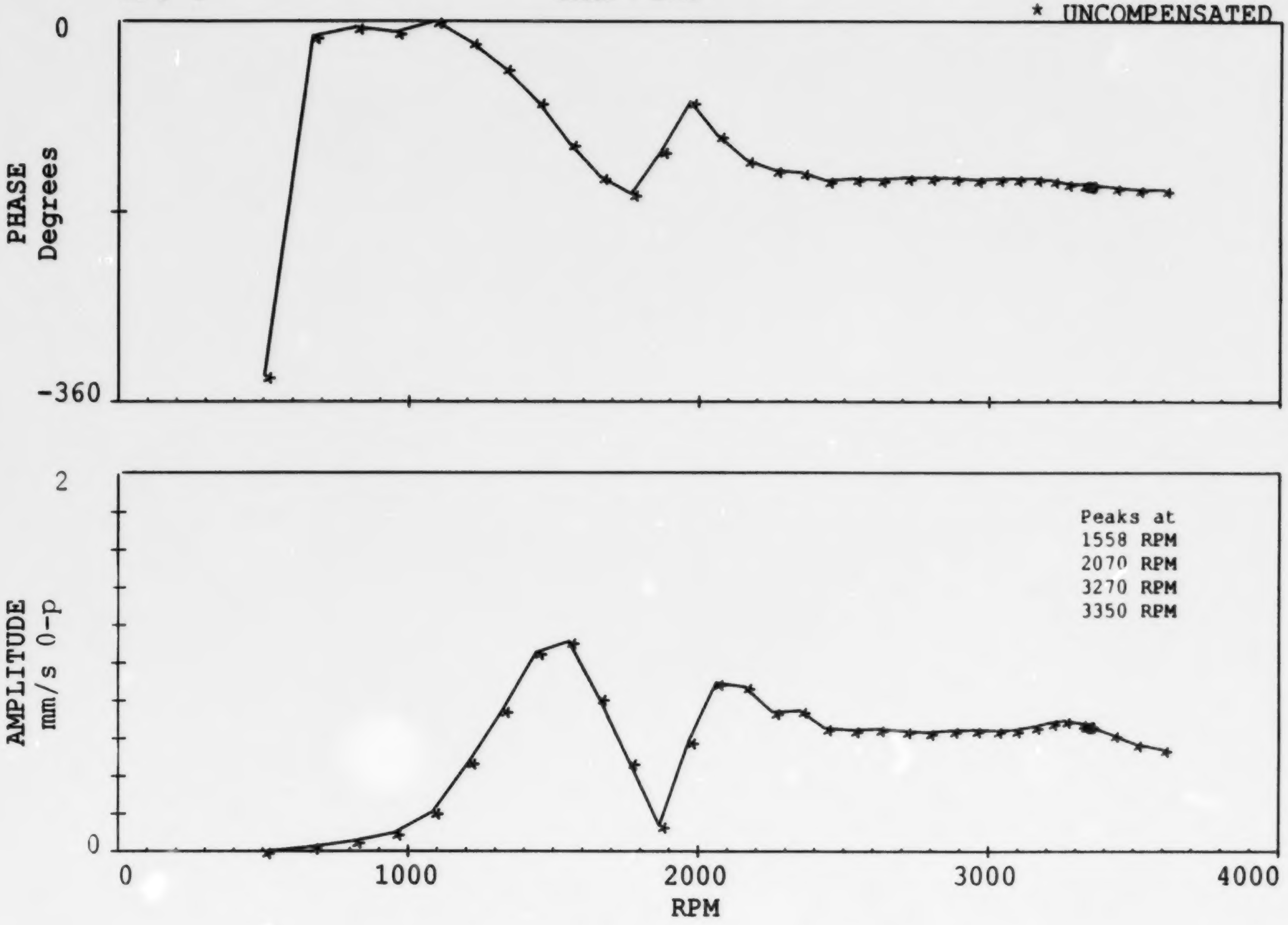


FIGURE 95

Darlington GS Standby Generator #3 - Cold Start
AC Generator Inboard Brg. Casing Velocity Y-Axis
BODE PLOT : Run-up
Ch # 4
Date : 27-Jan-1987
Order : 1.00

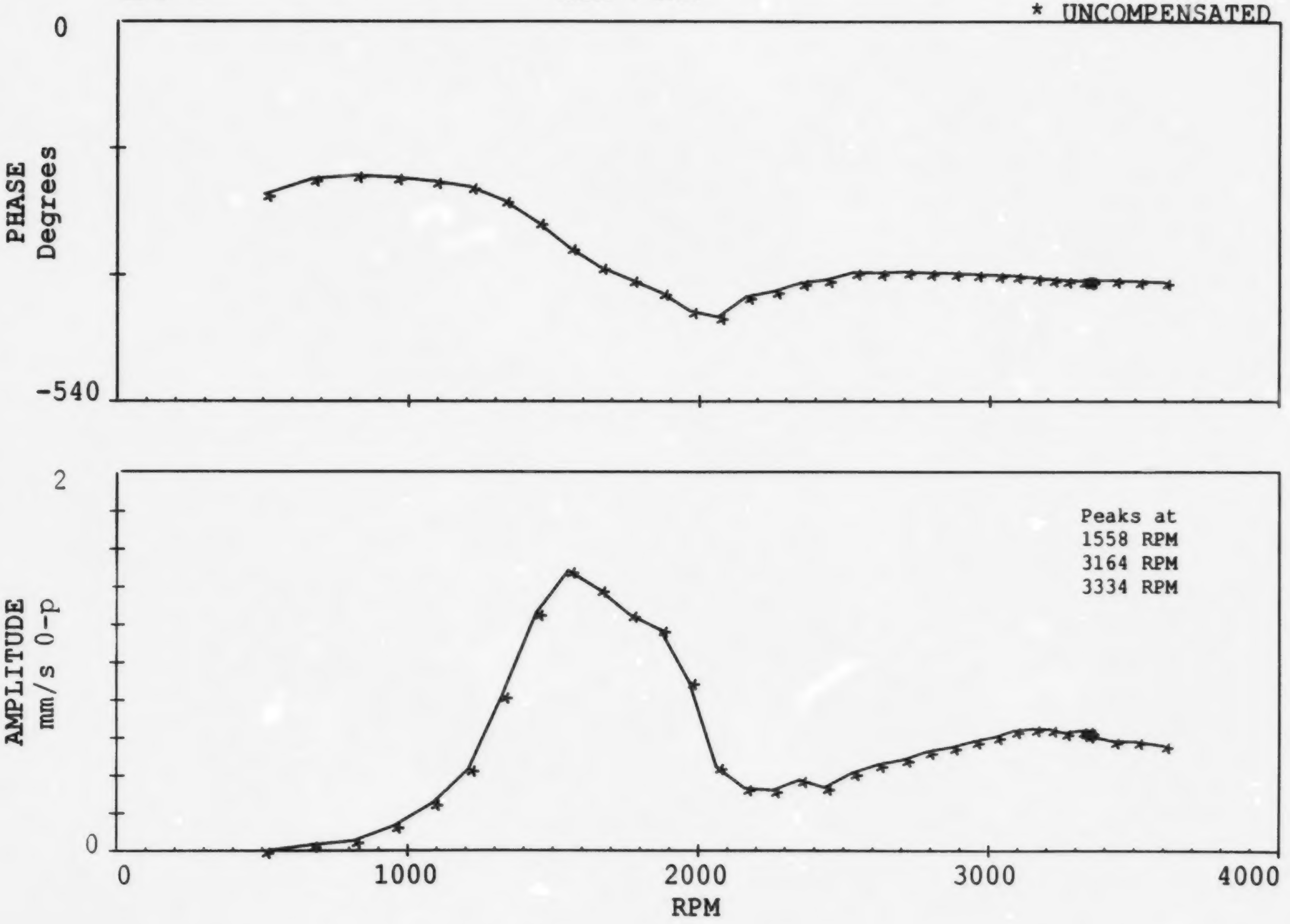


FIGURE 96

Darlington GS Standby Generator #3 - Cold Start
AC Generator Inboard Brg. Casing Velocity Axial

BODE PLOT : Run-up
Ch # 6

Date : 27-Jan-1987
Order : 1.00

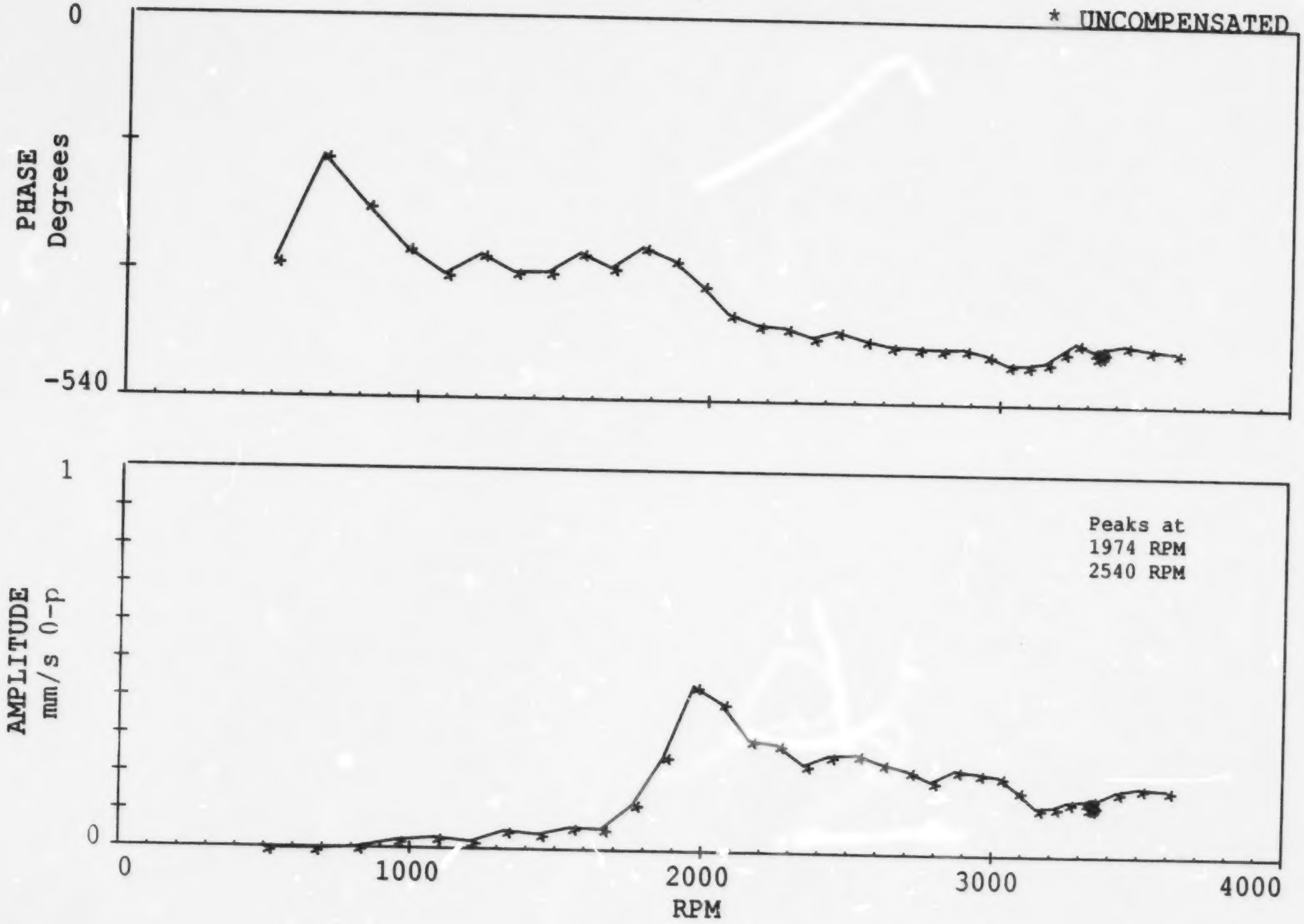


FIGURE 97

Darlington GS Standby Generator #3 - Cold Start
AC Generator Inboard Brg. Shaft Displacement Y-Axis

BODE PLOT : Run-up
Ch # 7

Date : 27-Jan-1987
Order : 1.00

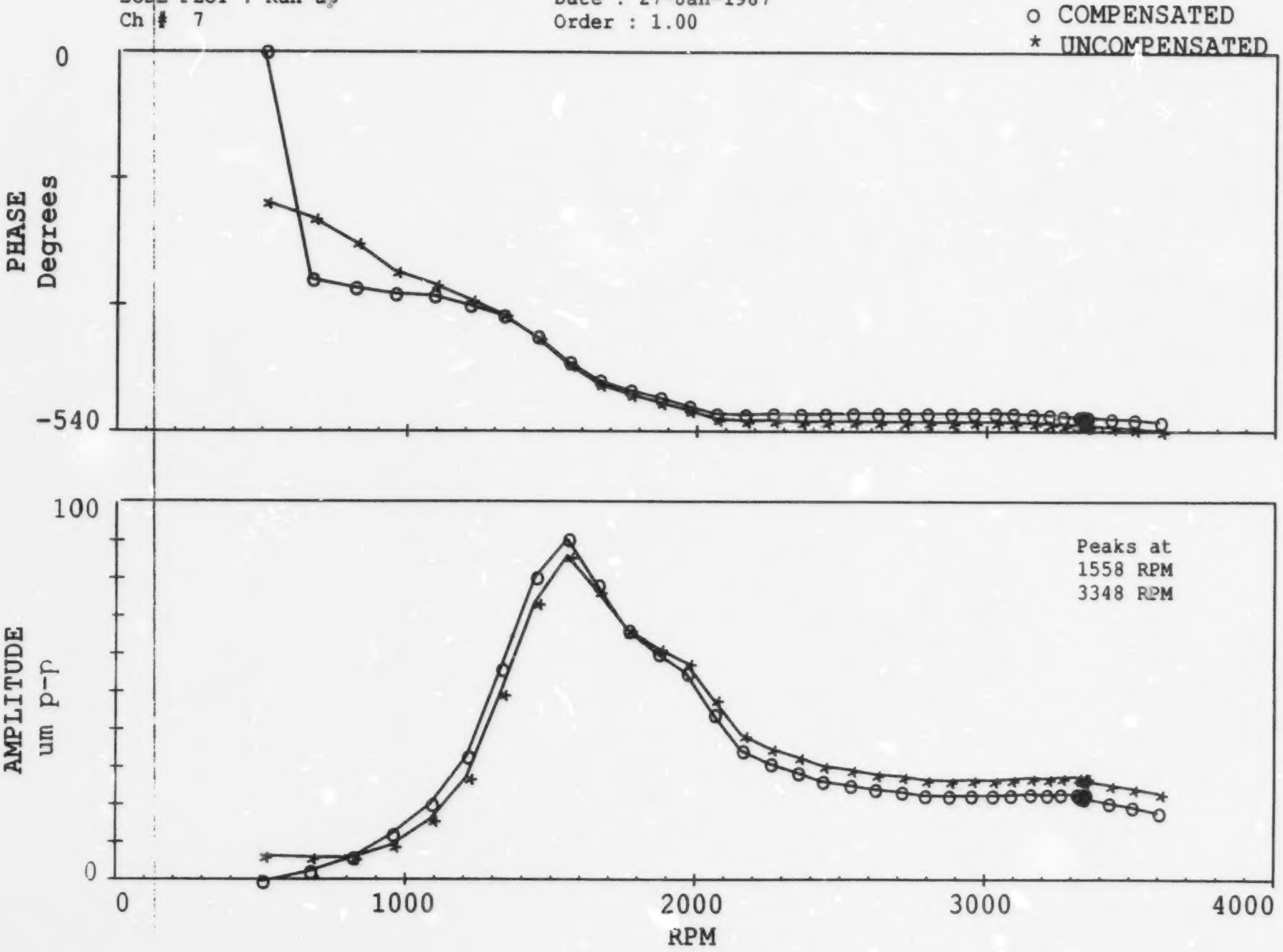


FIGURE 98

Darlington GS Standby Generator #3 - Cold Start
AC Generator Inboard Brg. Shaft Displacement X-Axis

BODE PLOT : Run-up
Ch # 8

Date : 27-Jan-1987
Order : 1.00

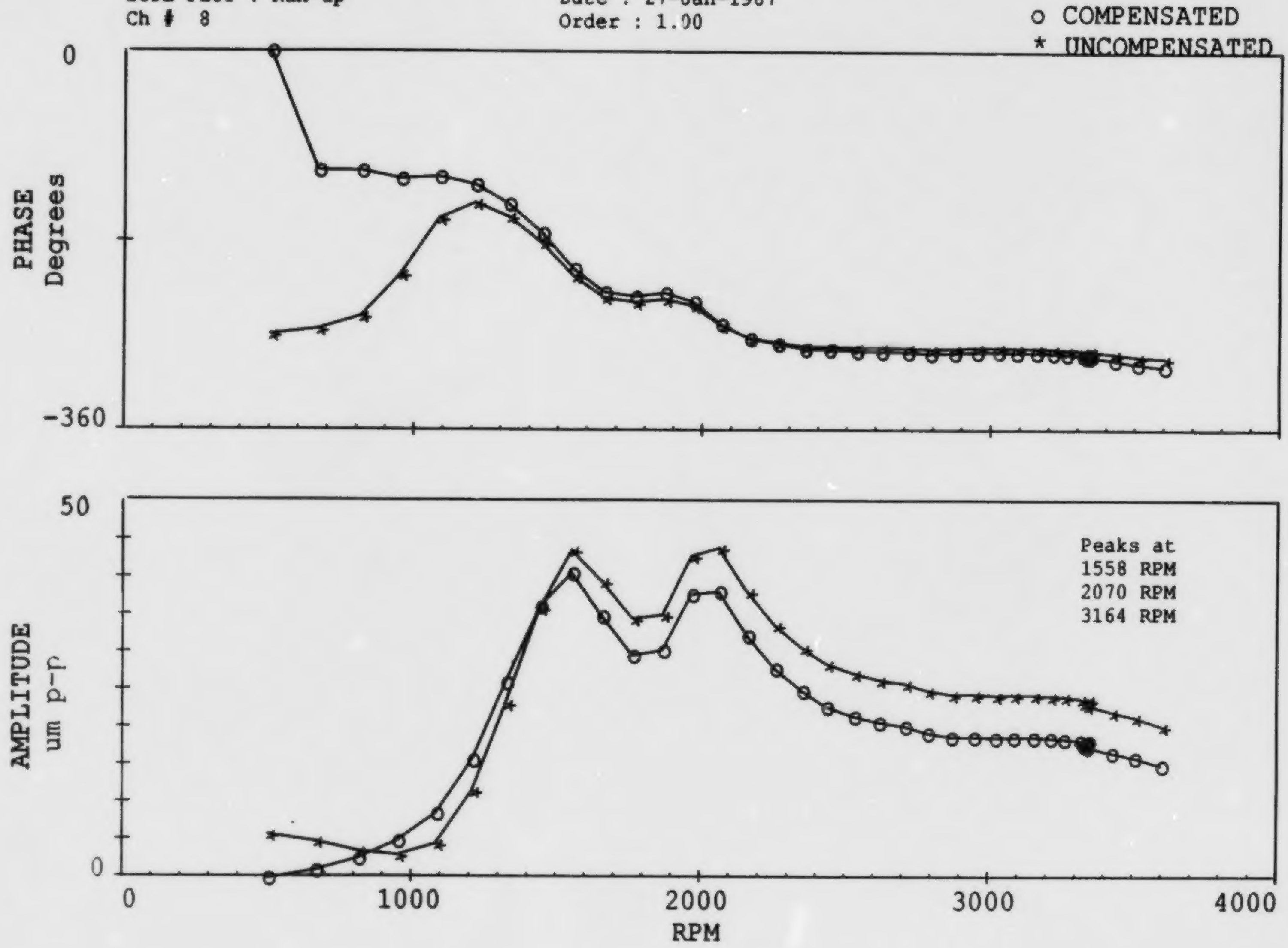
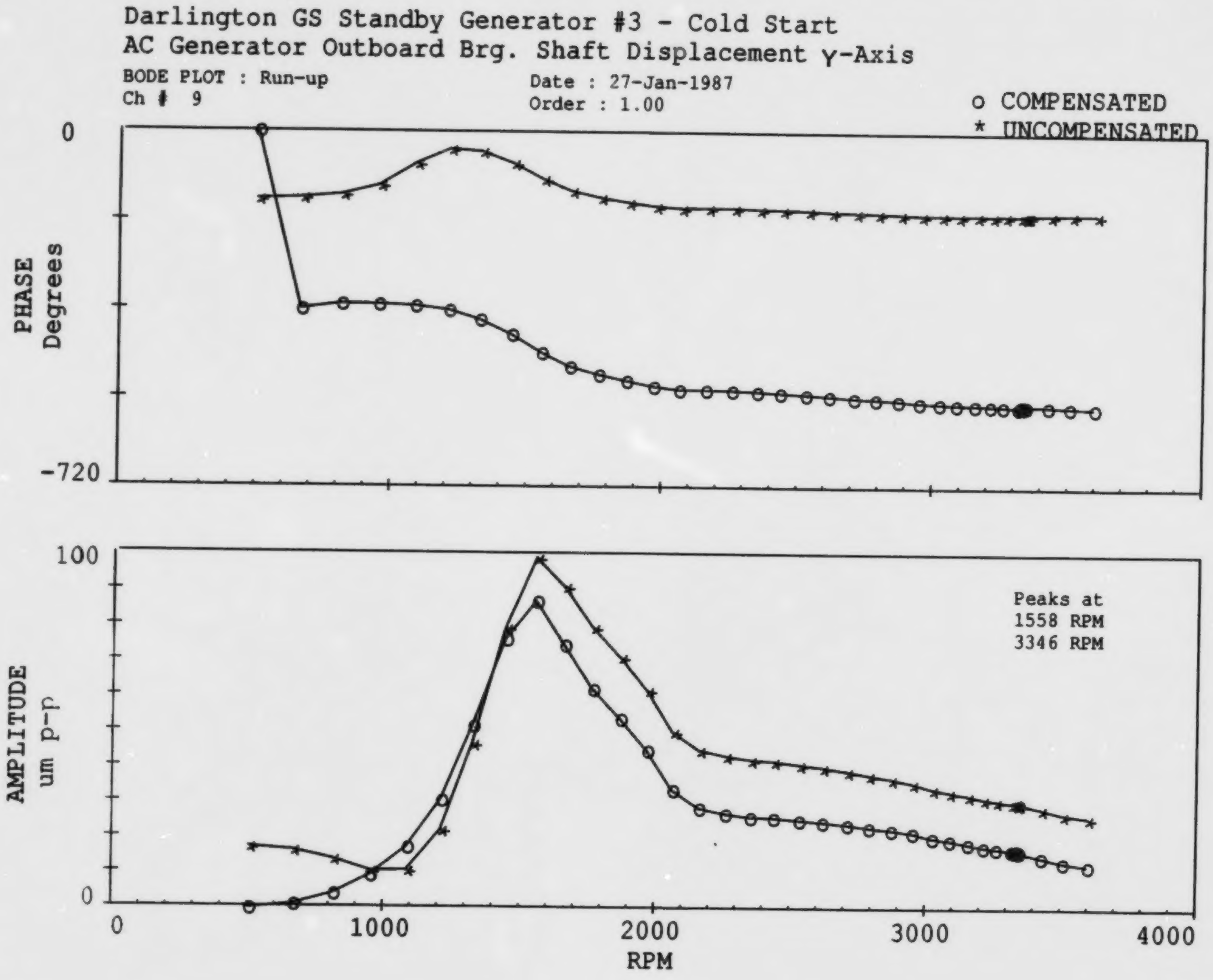


FIGURE 99



Darlington GS Standby Generator #3 - Cold Start
AC Generator Outboard Brg. Shaft Displacement Y-Axis

BODE PLOT : Run-up
Ch # 9

Date : 27-Jan-1987
Order : 1.00

FIGURE 100

Darlington GS Standby Generator #3 - Cold Start
AC Generator Outboard Brg. Shaft Displacement X-Axis

BODE PLOT : Run-up
Ch # 10

Date : 27-Jan-1987
Order : 1.00

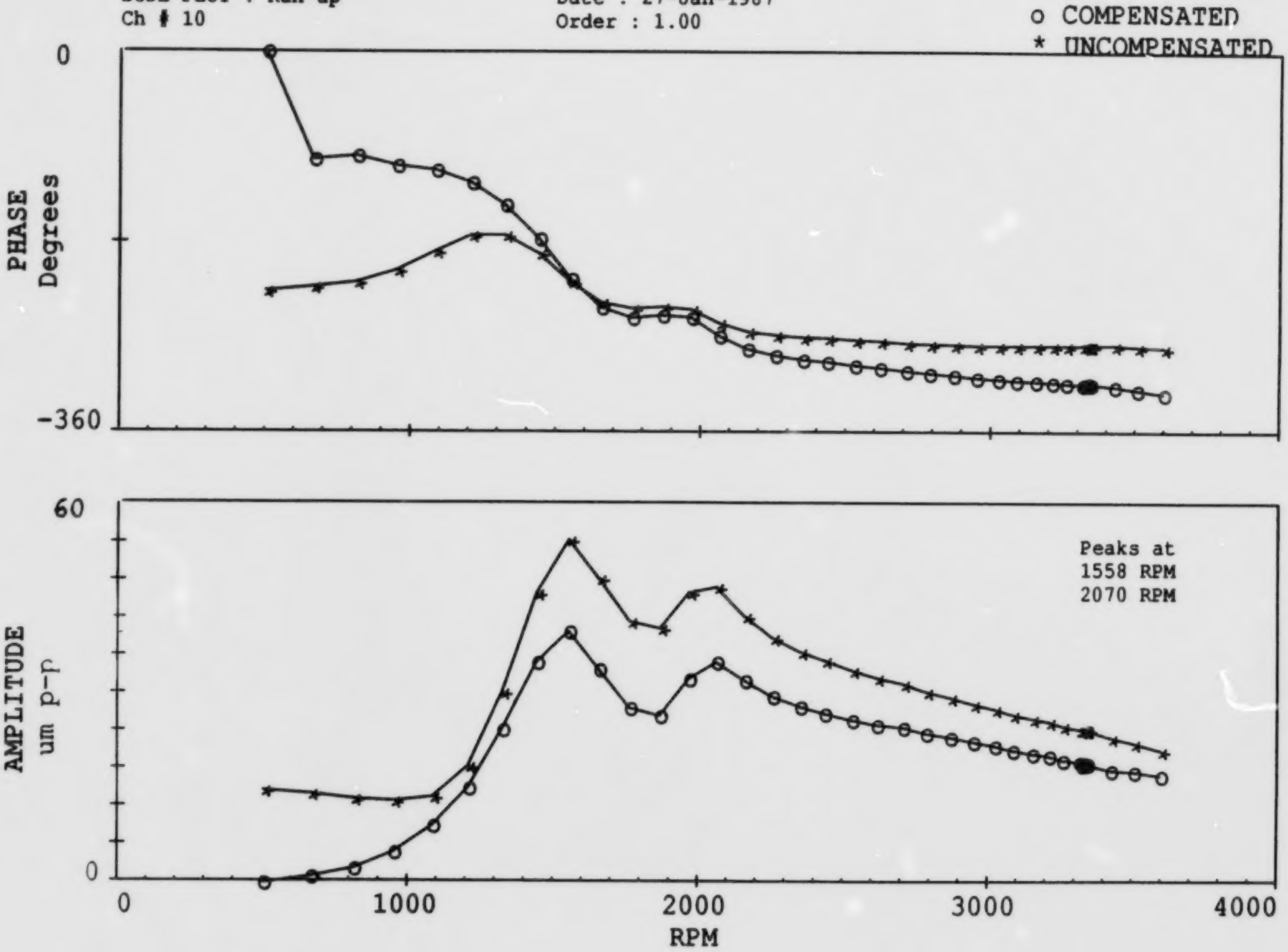


FIGURE 101

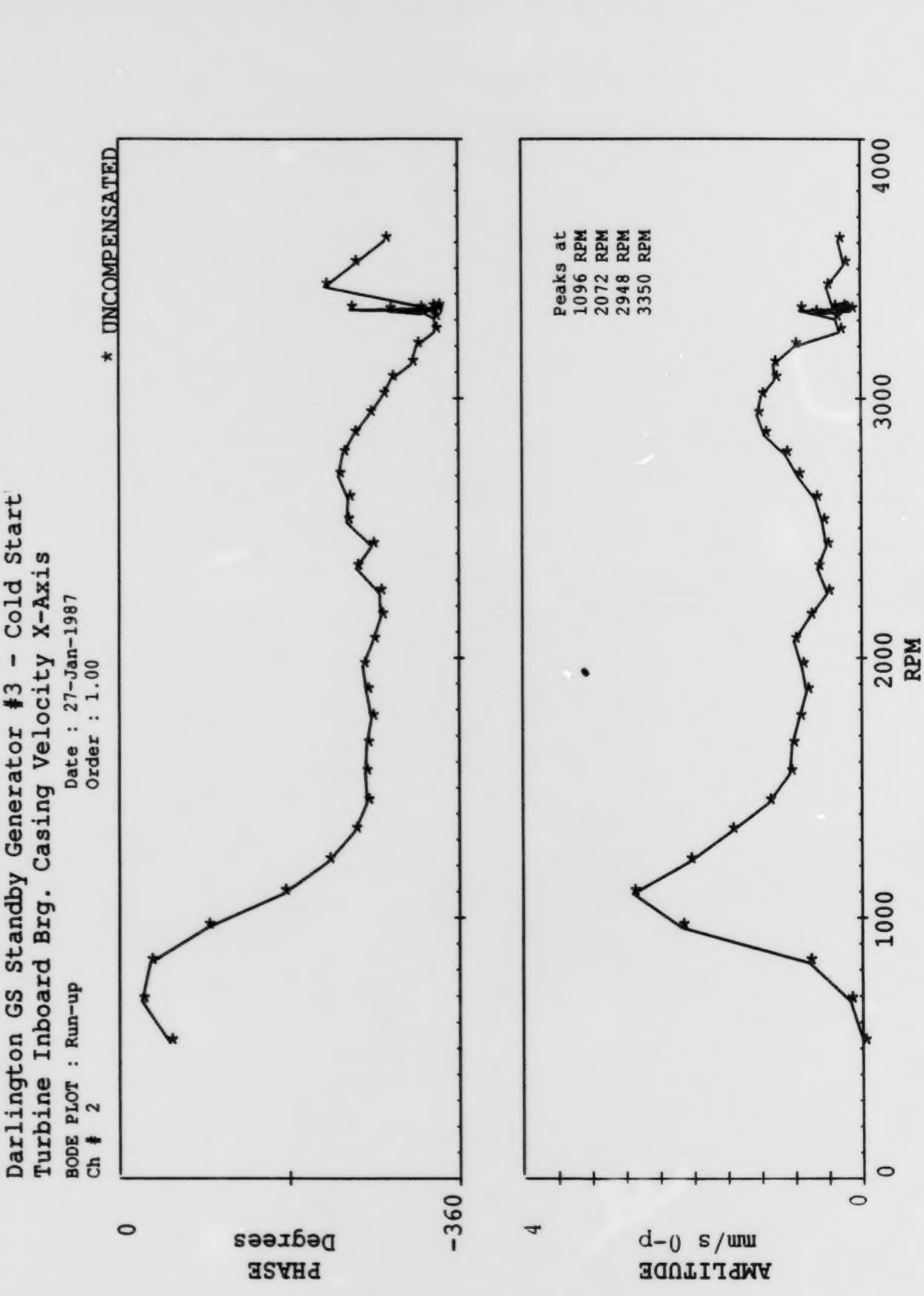

Darlington GS Standby Generator #3 - Cold Start
Turbine Inboard Brg. Casing Velocity X-Axis
BODE PLOT : Run-up
Ch # 2
Date : 27-Jan-1987
Order : 1.00
* UNCOMPENSATED
PHASE
Degrees
0
-360
AMPLITUDE
mm/s 0-p
4
0
Peaks at
1096 RPM
2072 RPM
2948 RPM
3350 RPM
0
1000
2000
3000
4000
RPM

FIGURE 102

Darlington GS Standby Generator #3 - Cold Start
Turbine Inboard Brg. Casing Velocity Y-Axis
BODE PLOT : Run-up
Ch # 1
Date : 27-Jan-1987
Order : 1.00

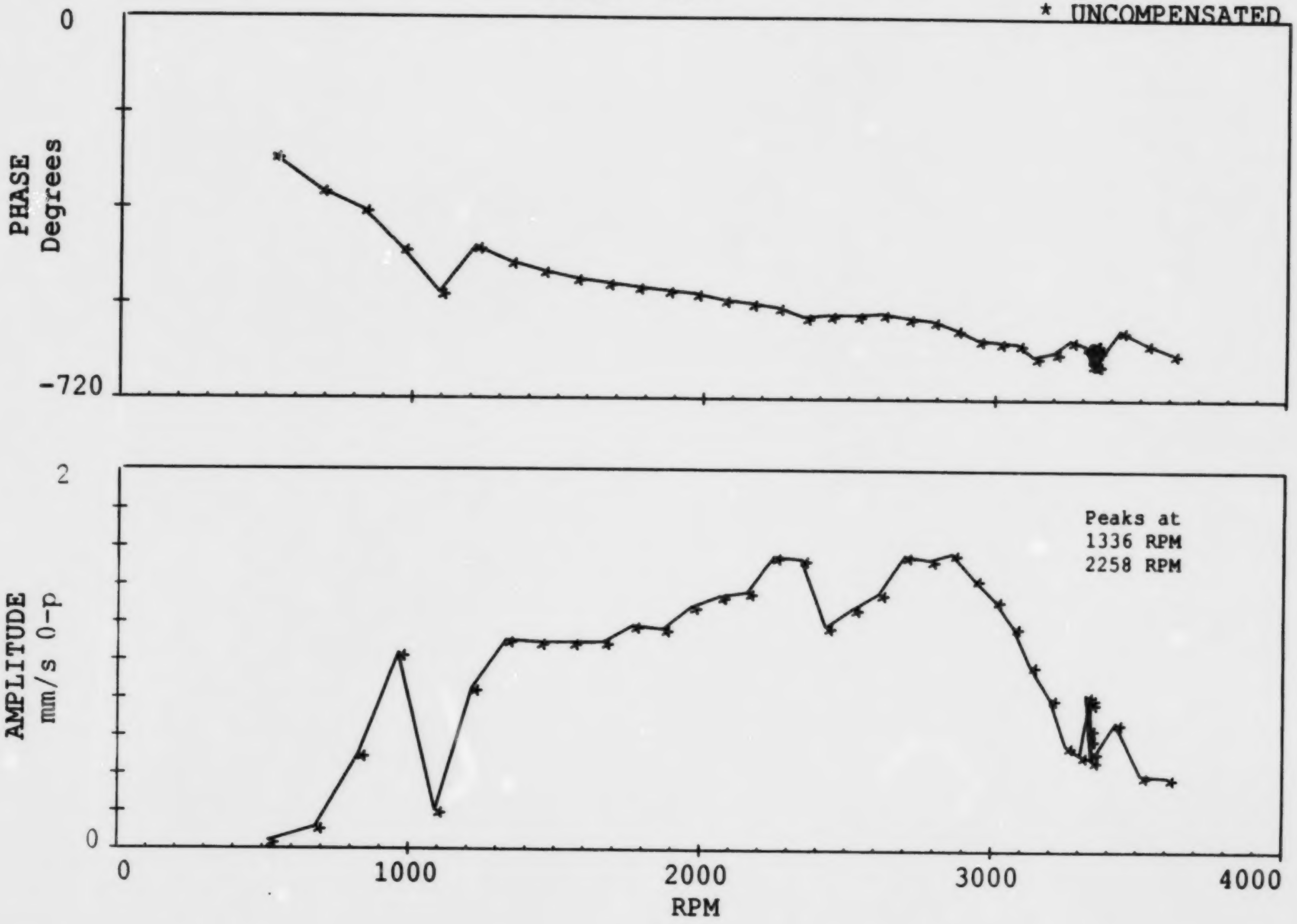


FIGURE 103

Darlington GS Standby Generator #3 - Cold Start
Turbine Inboard Brg. Casing Velocity Axial

BODE PLOT : Run-up
Ch # 3

Date : 27-Jan-1987
Order : 1.00

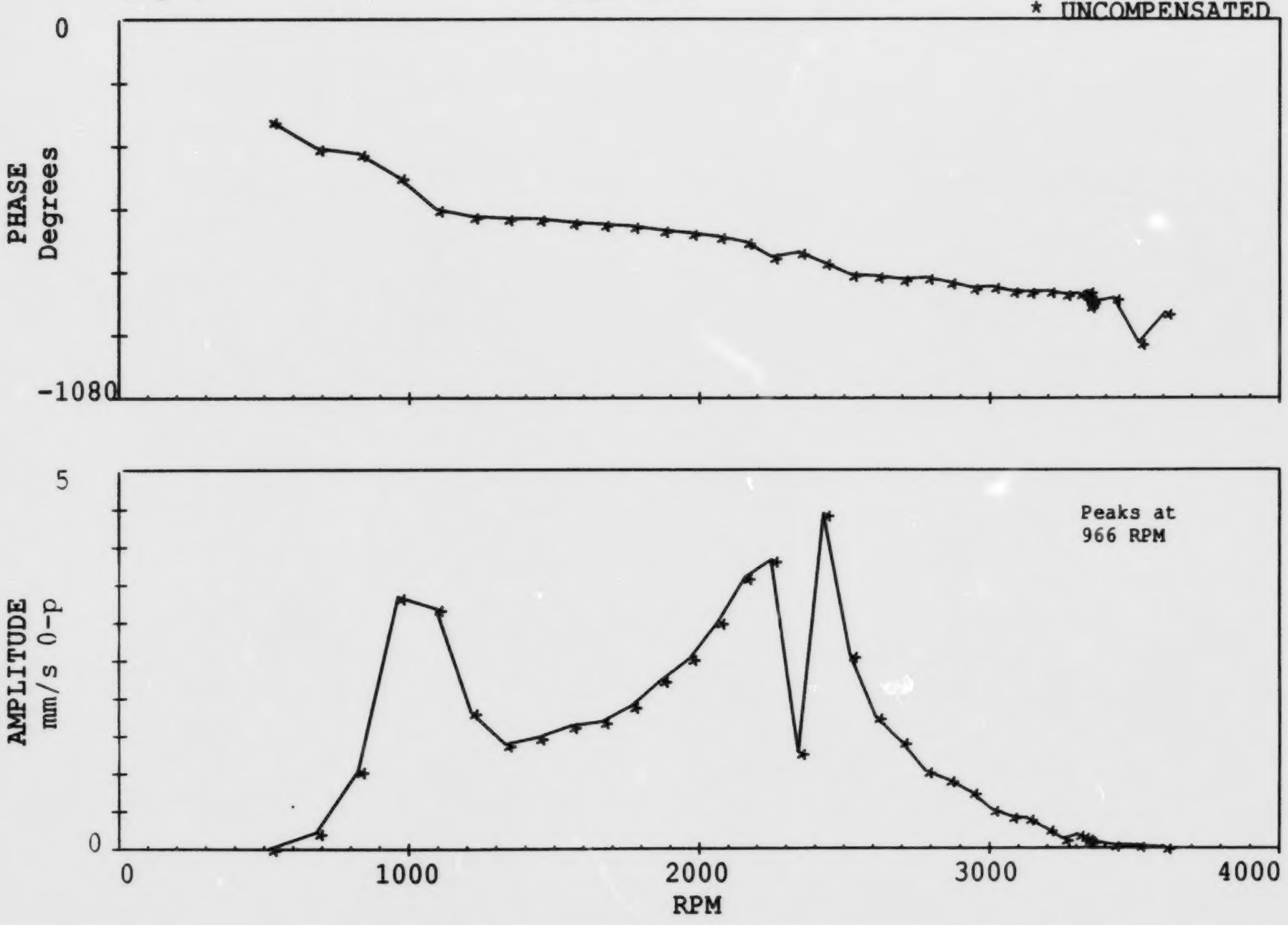


FIGURE 104

Darlington GS Standby Generator #3 - Cold Start
Turbine Inboard Brg. Shaft Displacement X-Axis

BODE PLOT : Run-up
Ch # 6

Date : 27-Jan-1987
Order : 1.00

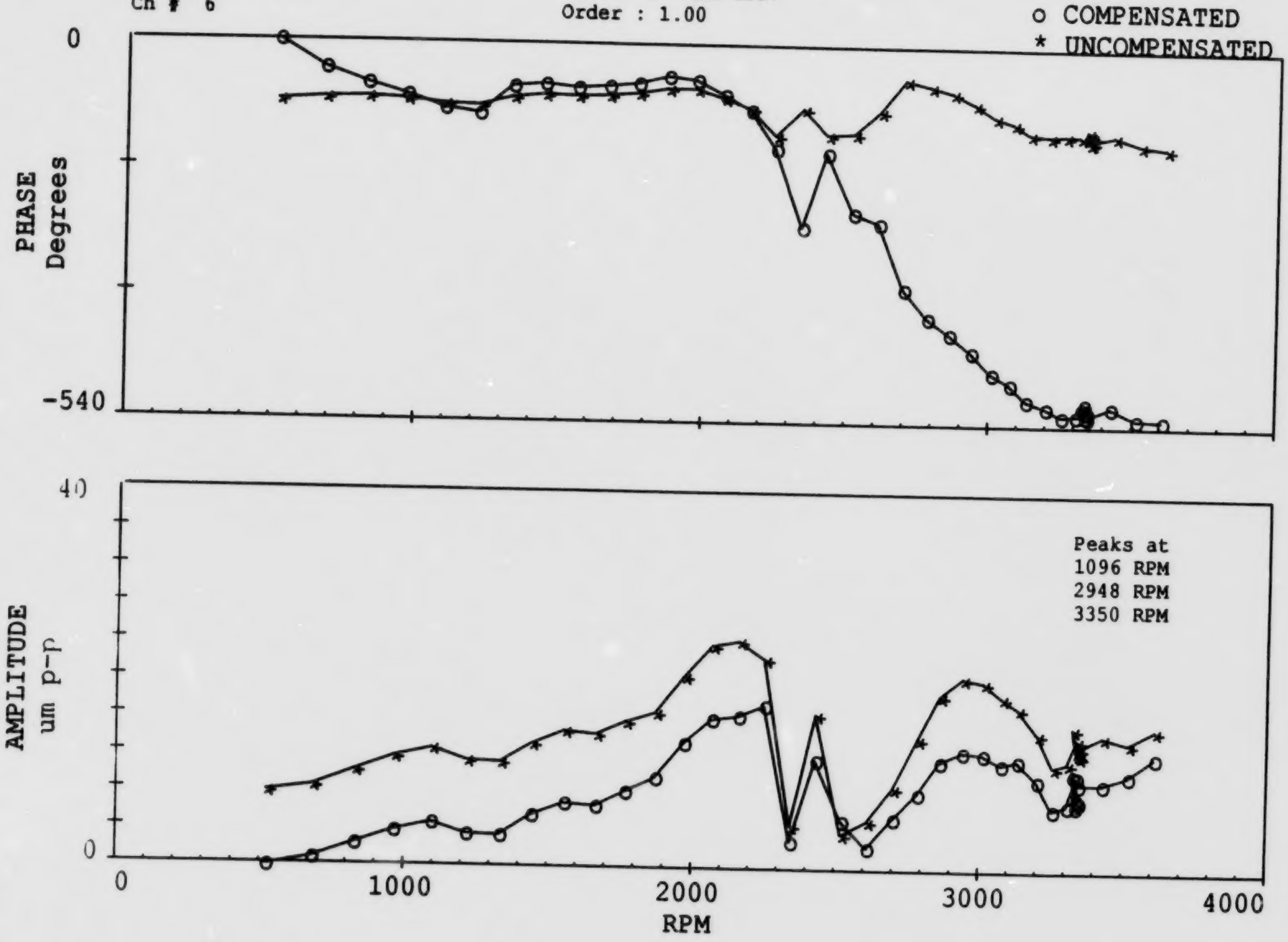


FIGURE 105

Darlington GS Standby Generator #3 - Cold Start
Turbine Inboard Brg. Shaft Displacement Y-Axis

BODE PLOT : Run-up
Ch # 7

Date : 27-Jan-1987
Order : 1.00

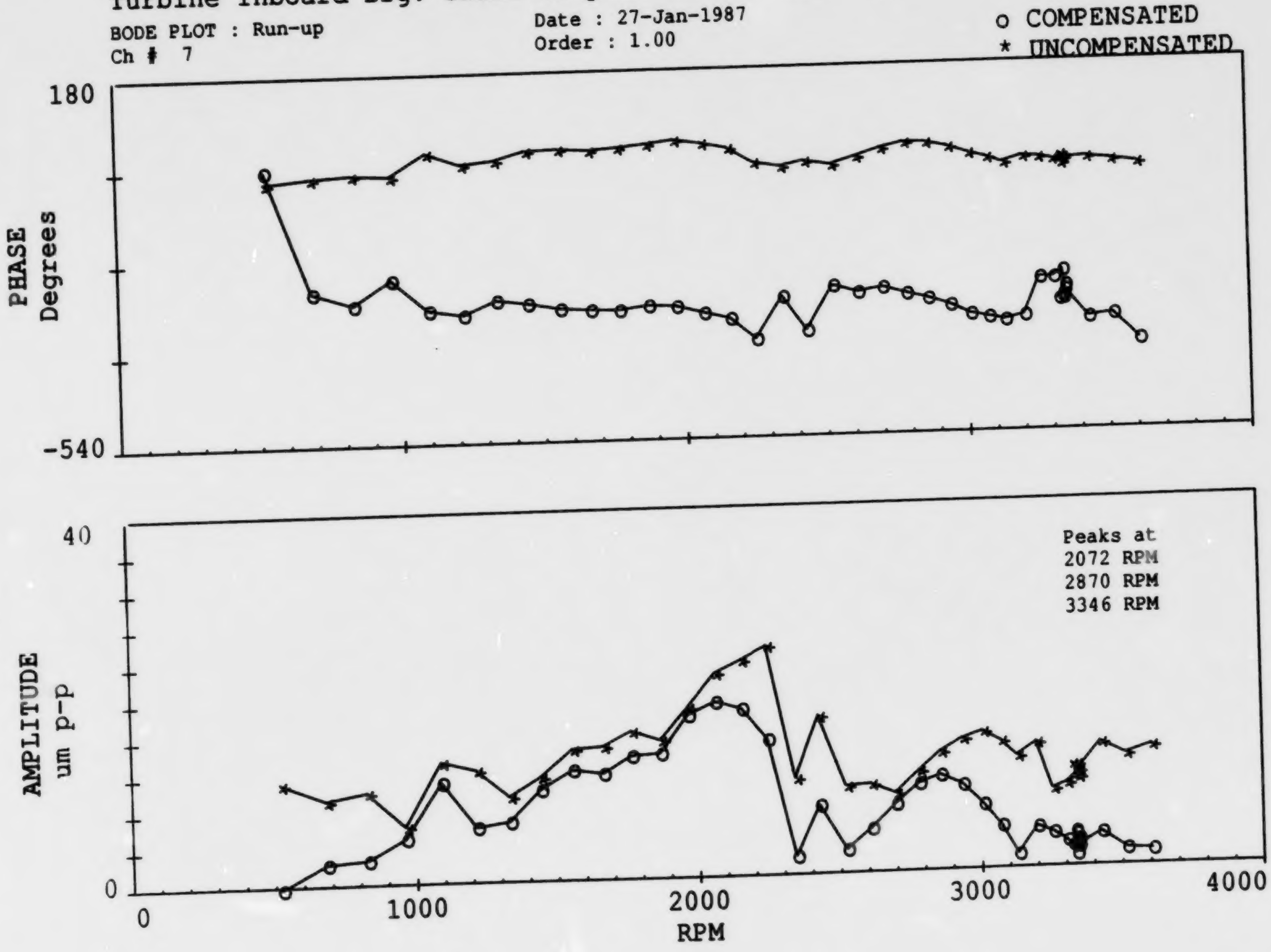


FIGURE 106

Darlington GS Standby Generator #3 - Cold Start
Turbine Outboard Brg. Shaft Displacement X-Axis

BODE PLOT : Run-up
Ch # 8

Date : 27-Jan-1987
Order : 1.00

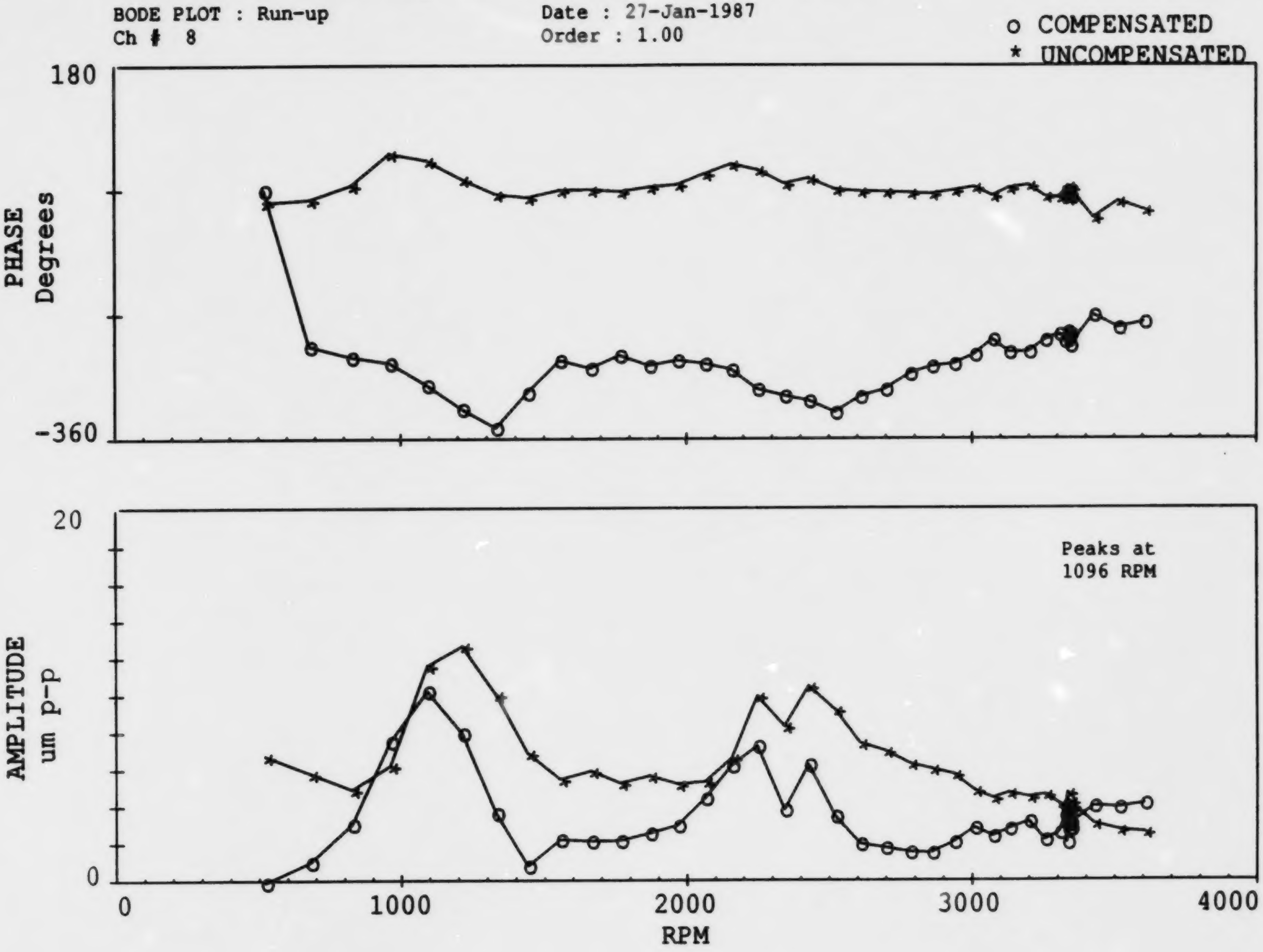


FIGURE 107

Darlington GS Standby Generator #3 - Cold Start
Turbine Outboard Brg. Shaft Displacement Y-Axis
BODE PLOT : Run-up
Ch # 9
Date : 27-Jan-1987
Order : 1.00

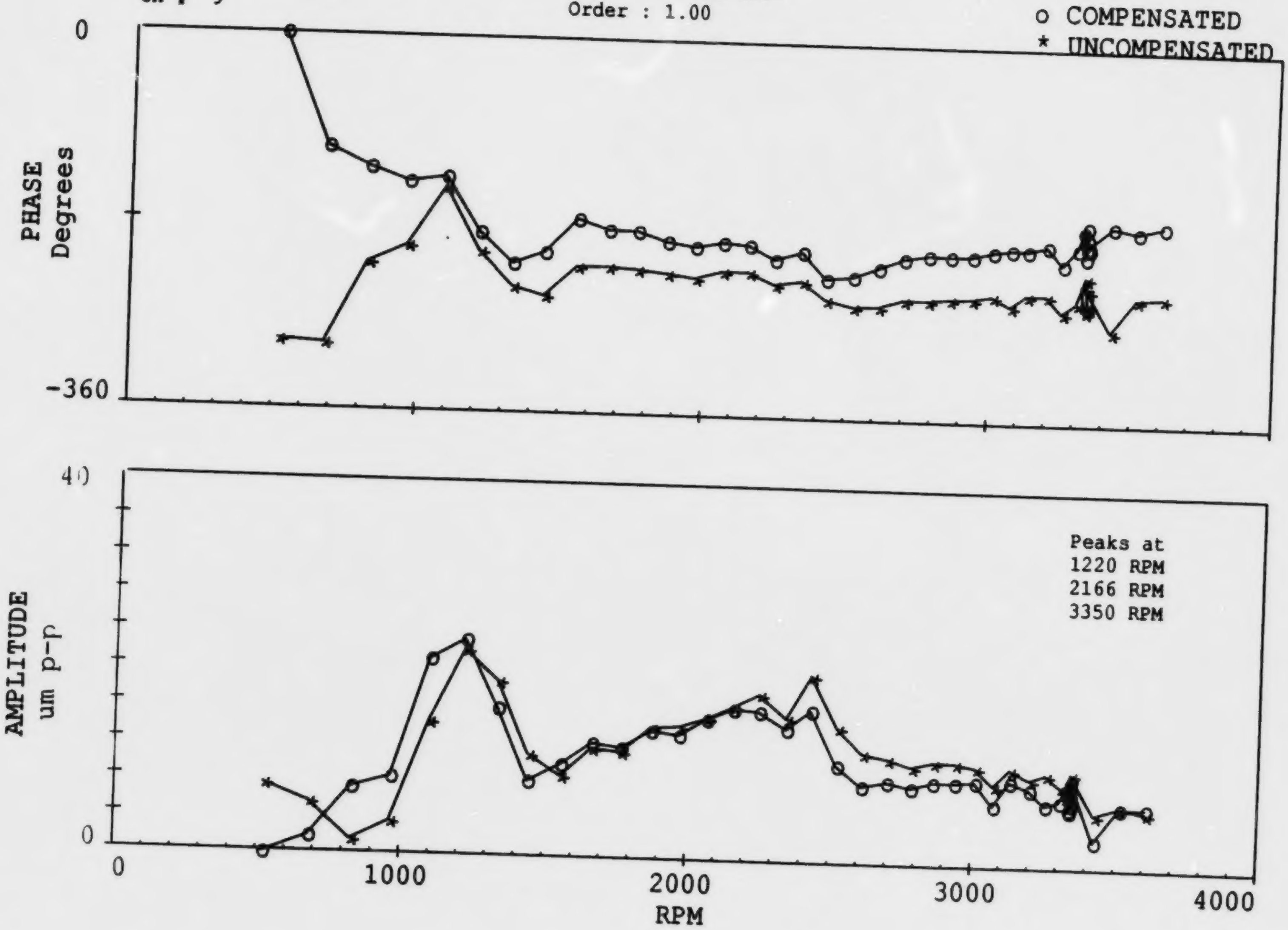


FIGURE 108

Darlington GS Standby Generator #3
AC Generator Outboard Brg. Casing Velocity X-Axis

BODE PLOT : Run-up
Ch # 2

Date : 27-Jan-1987
Order : 1.00

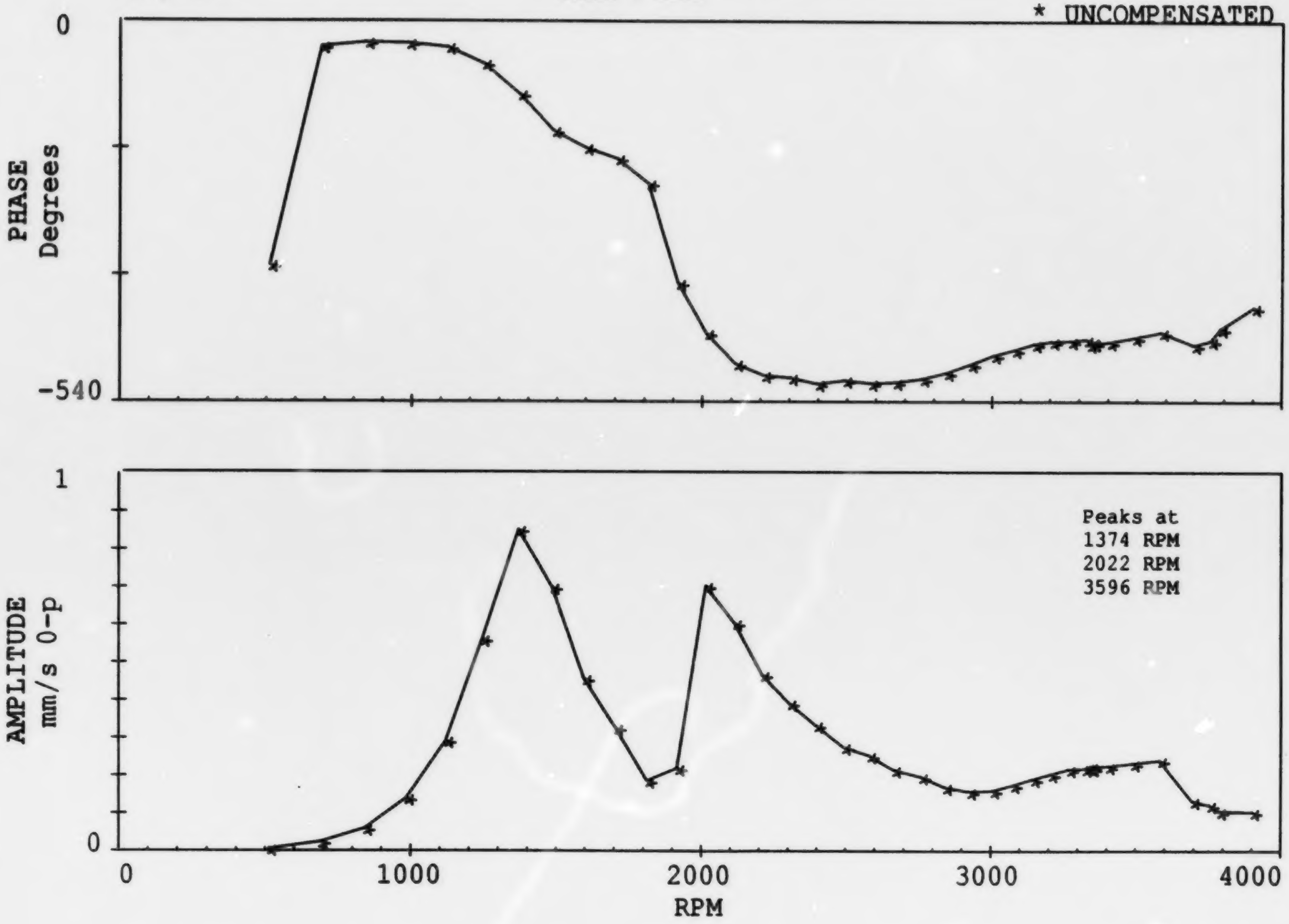


FIGURE 109

Darlington GS Standby Generator #3
AC Generator Outboard Brg. Casing Velocity Y-Axis

BODE PLOT : Run-up
Ch # 1

Date : 27-Jan-1987
Order : 1.00

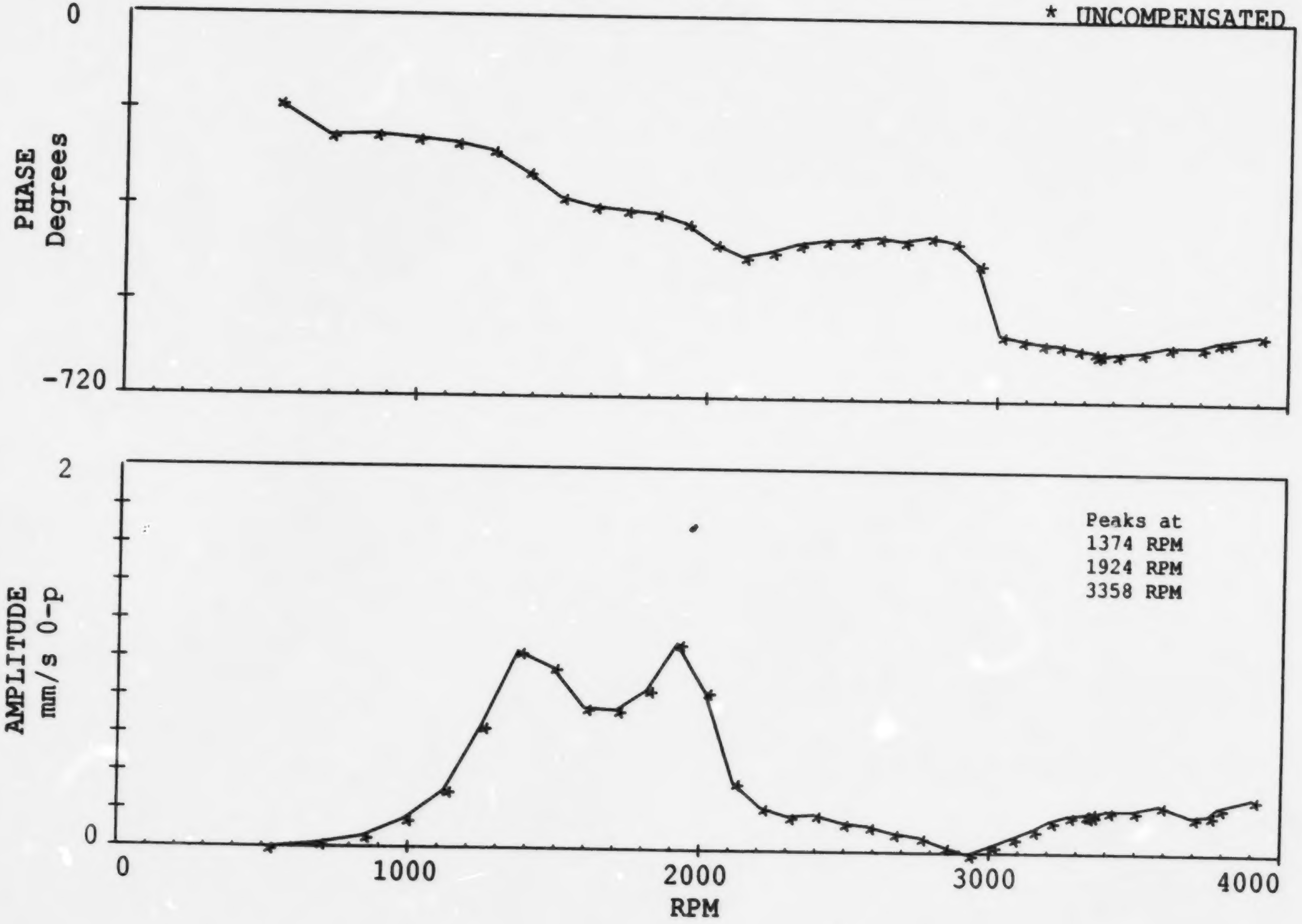


FIGURE 110

Darlington GS Standby Generator #3
AC Generator Outboard Brg. Casing Velocity Axial

BODE PLOT : Run-up
Ch # 3

Date : 27-Jan-1987
Order : 1.00

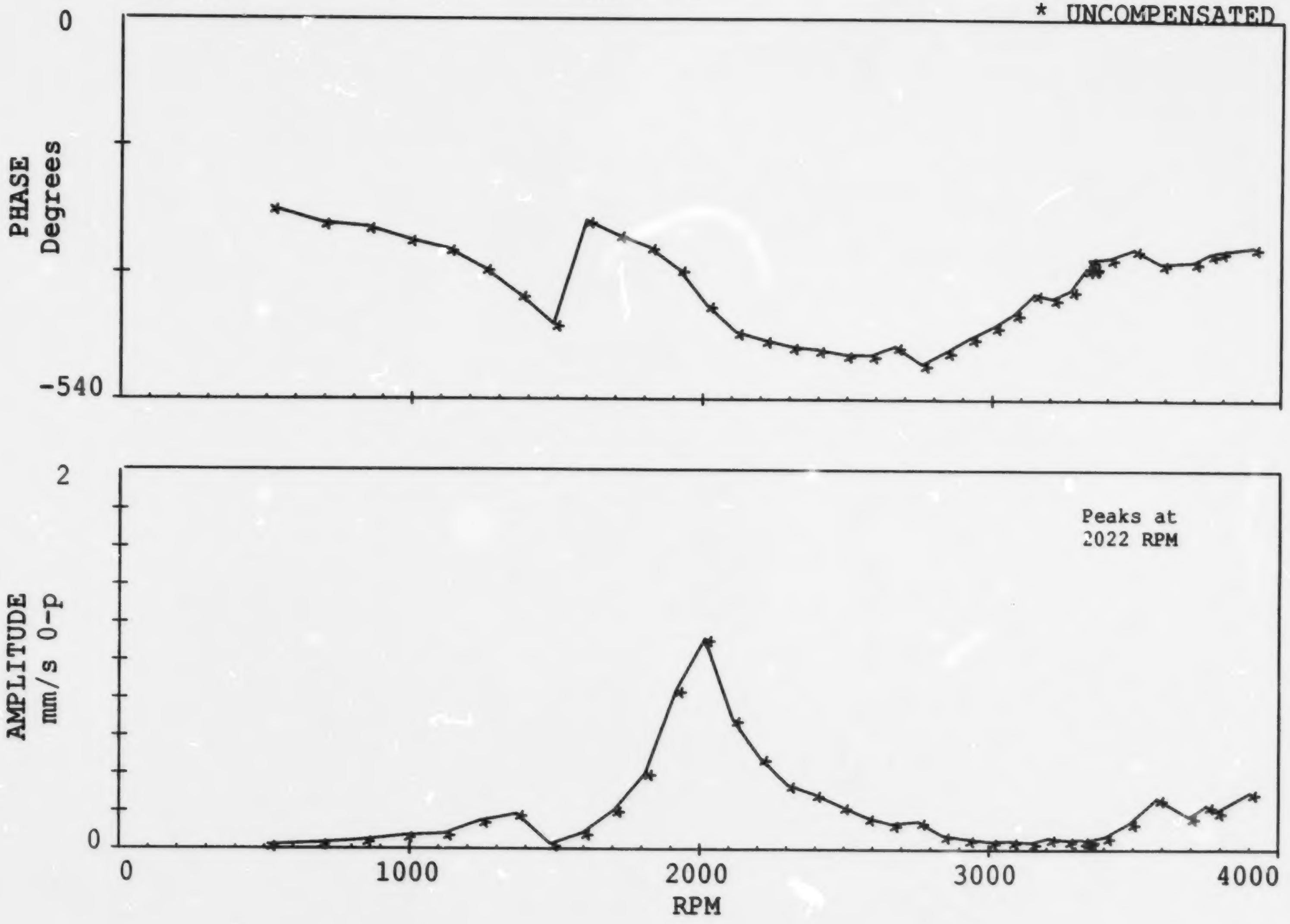


FIGURE 111

Darlington GS Standby Generator #3
AC Generator Inboard Brg. Casing Velocity X-Axis
BODE PLOT : Run-up
Ch # 5
Date : 27-Jan-1987
Order : 1.00

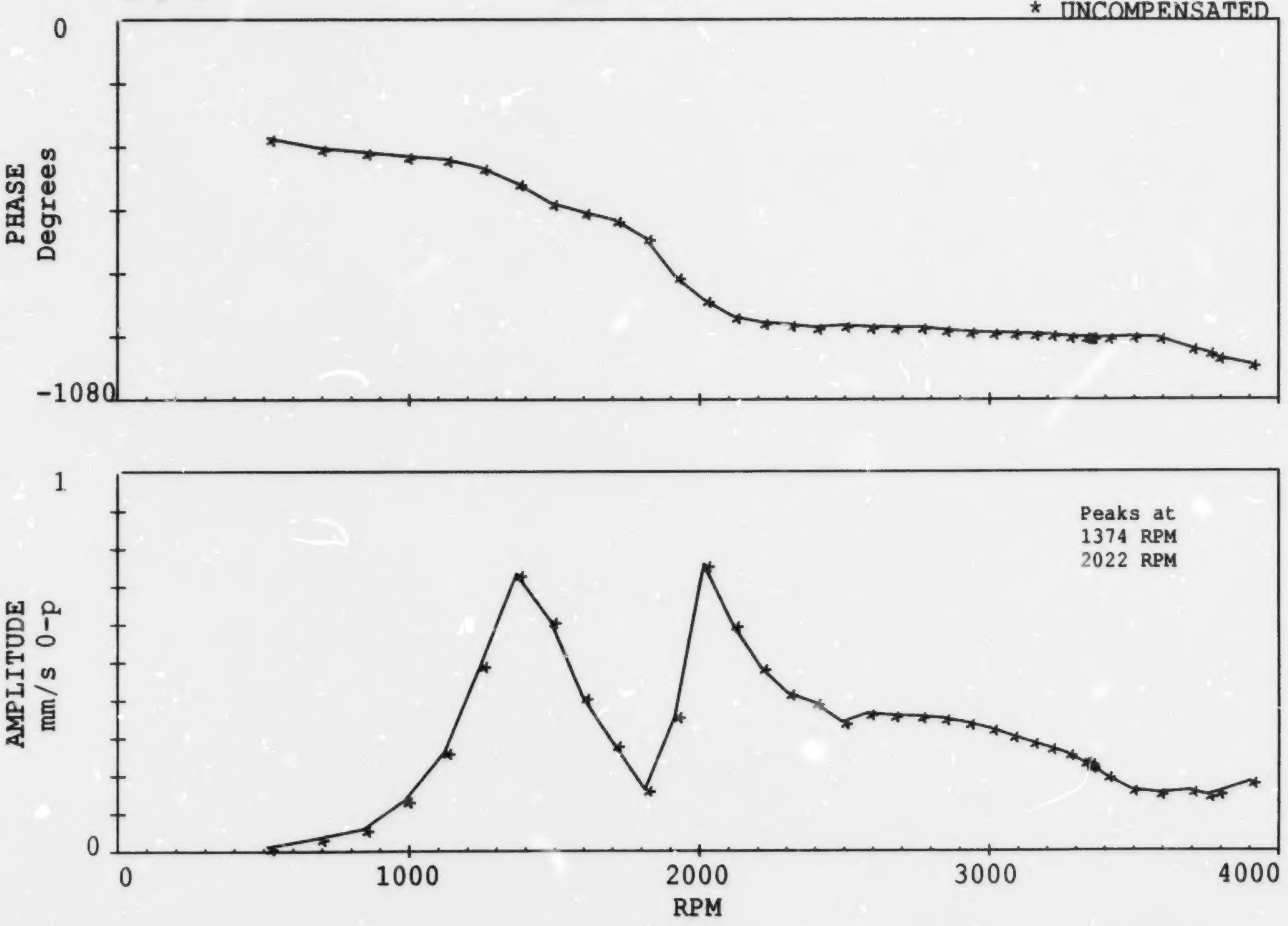


FIGURE 112

Darlington GS Standby Generator #3
AC Generator Inboard Brg. Casing Velocity Y-Axis

BODE PLOT : Run-up
Ch # 4

Date : 27-Jan-1987
Order : 1.00

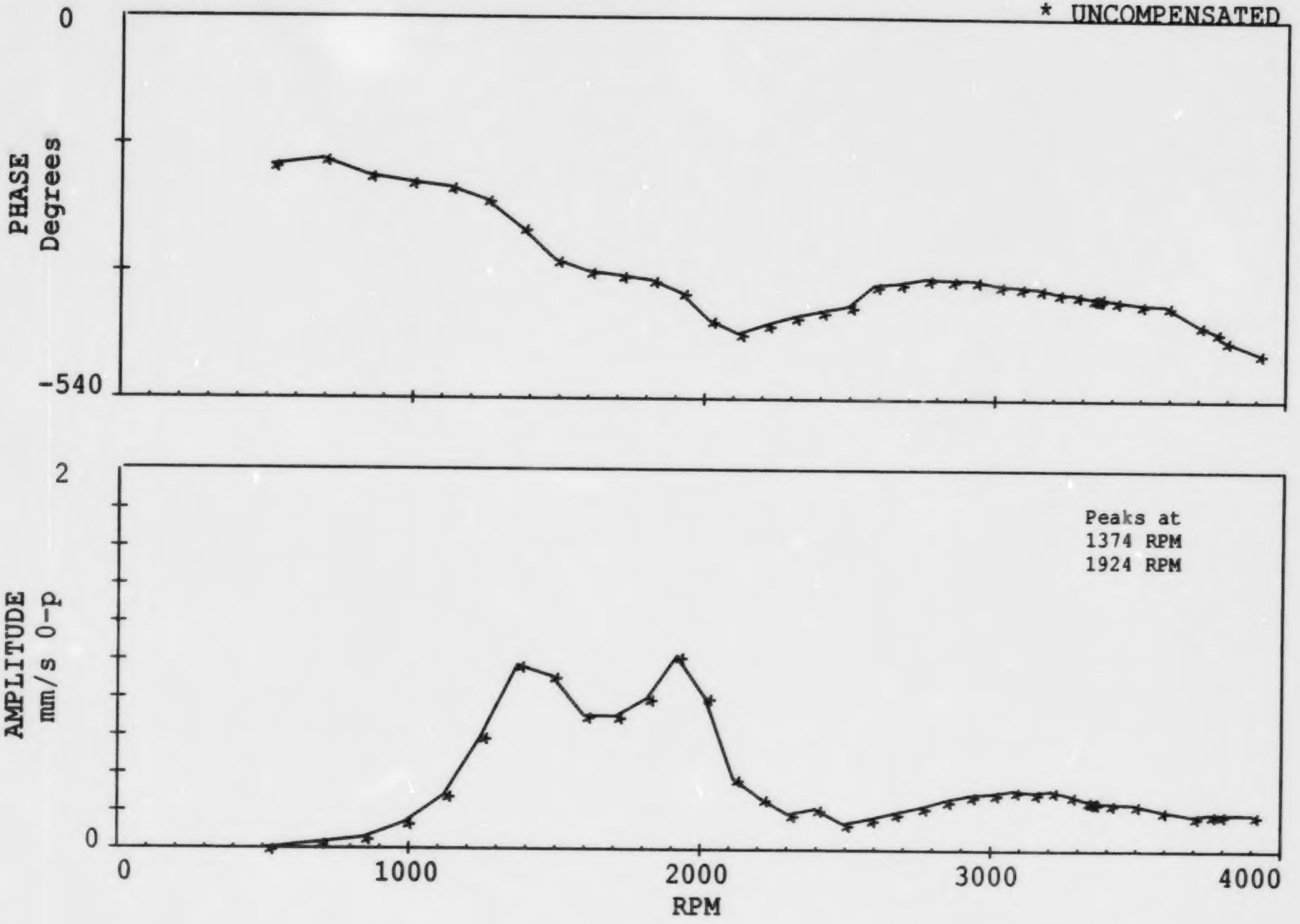


FIGURE 113

Darlington GS Standby Generator #3
AC Generator Inboard Brg. Casing Velocity Axial
BODE PLOT : Run-up
Ch # 6

Date : 27-Jan-1987
Order : 1.00

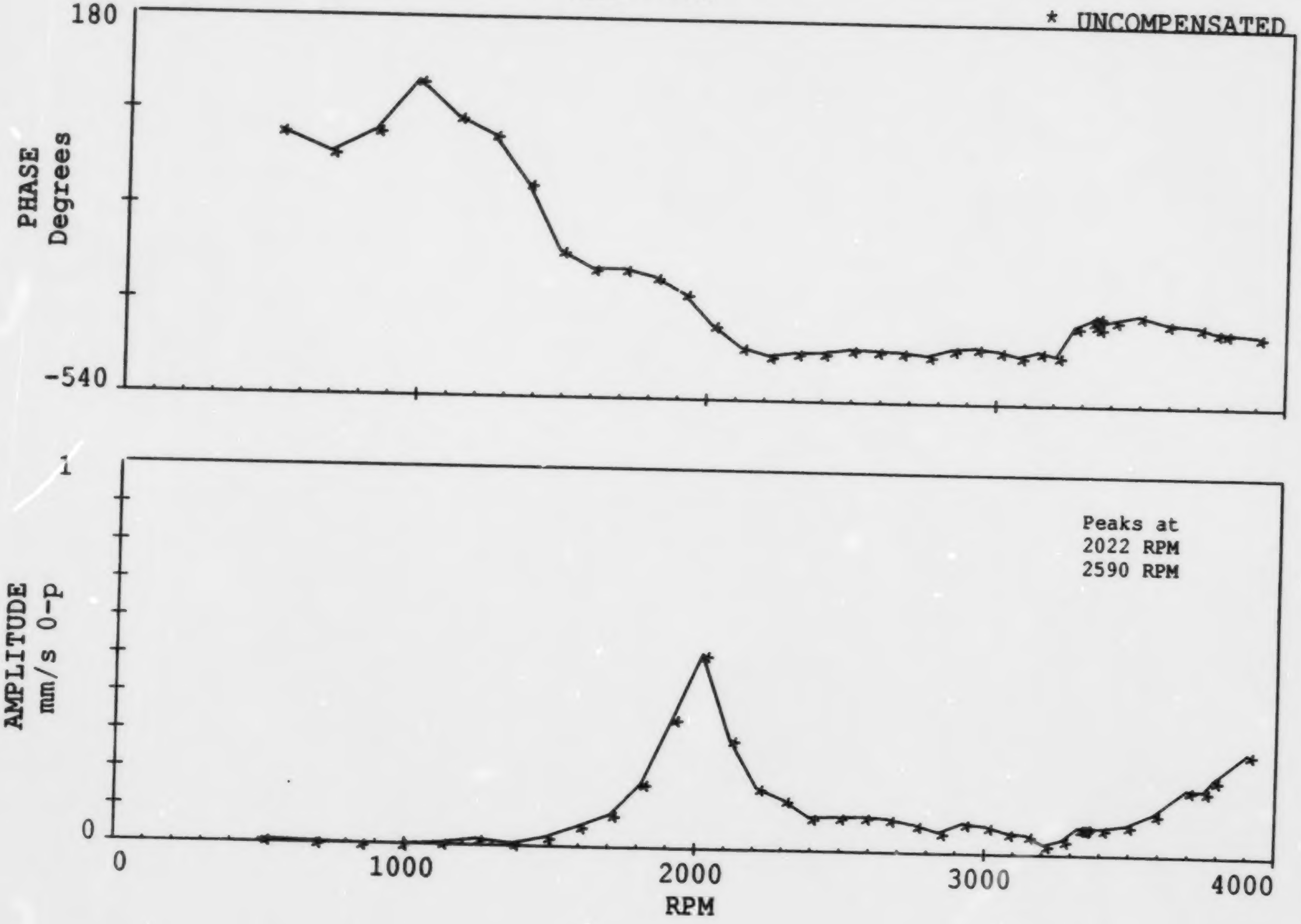
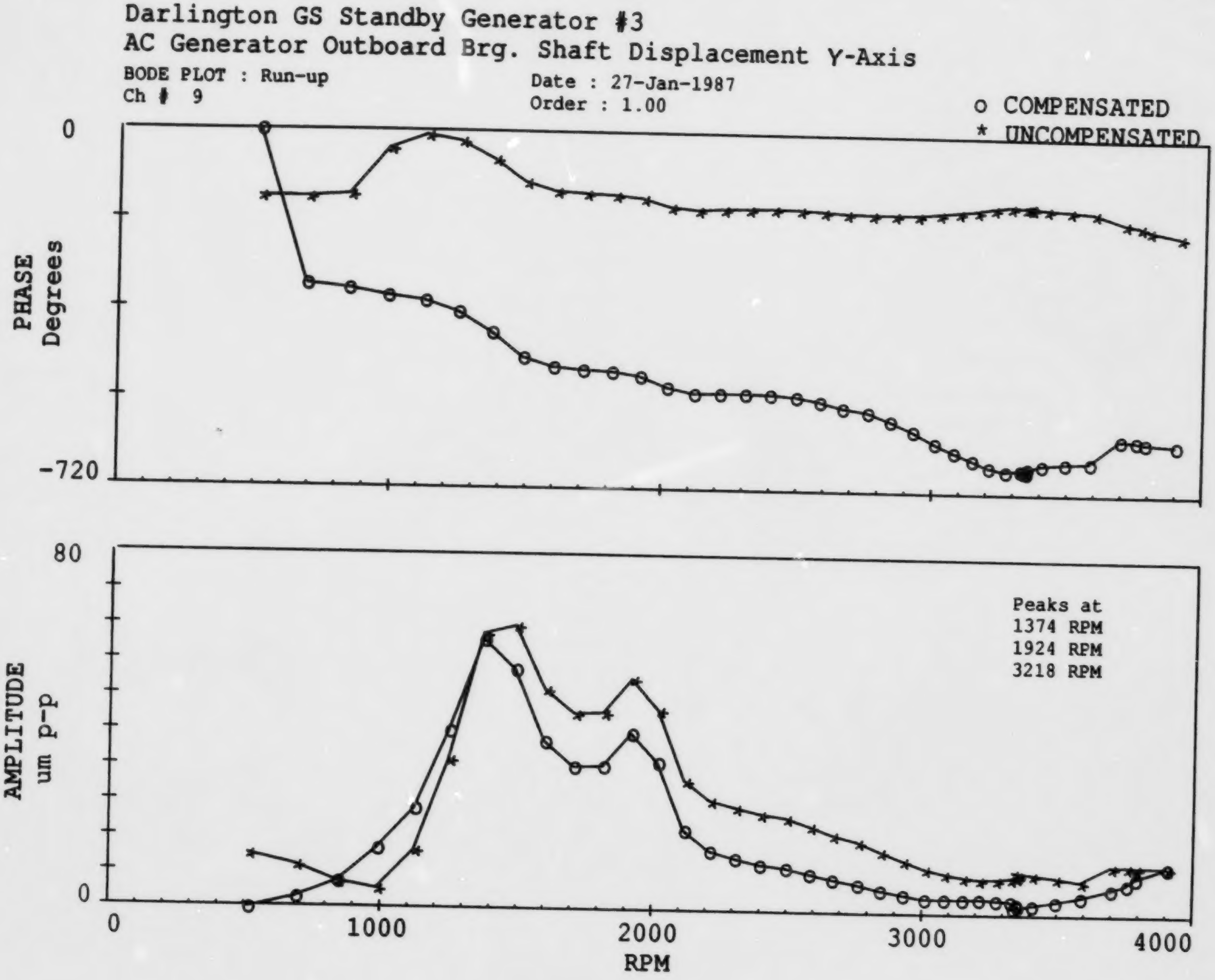
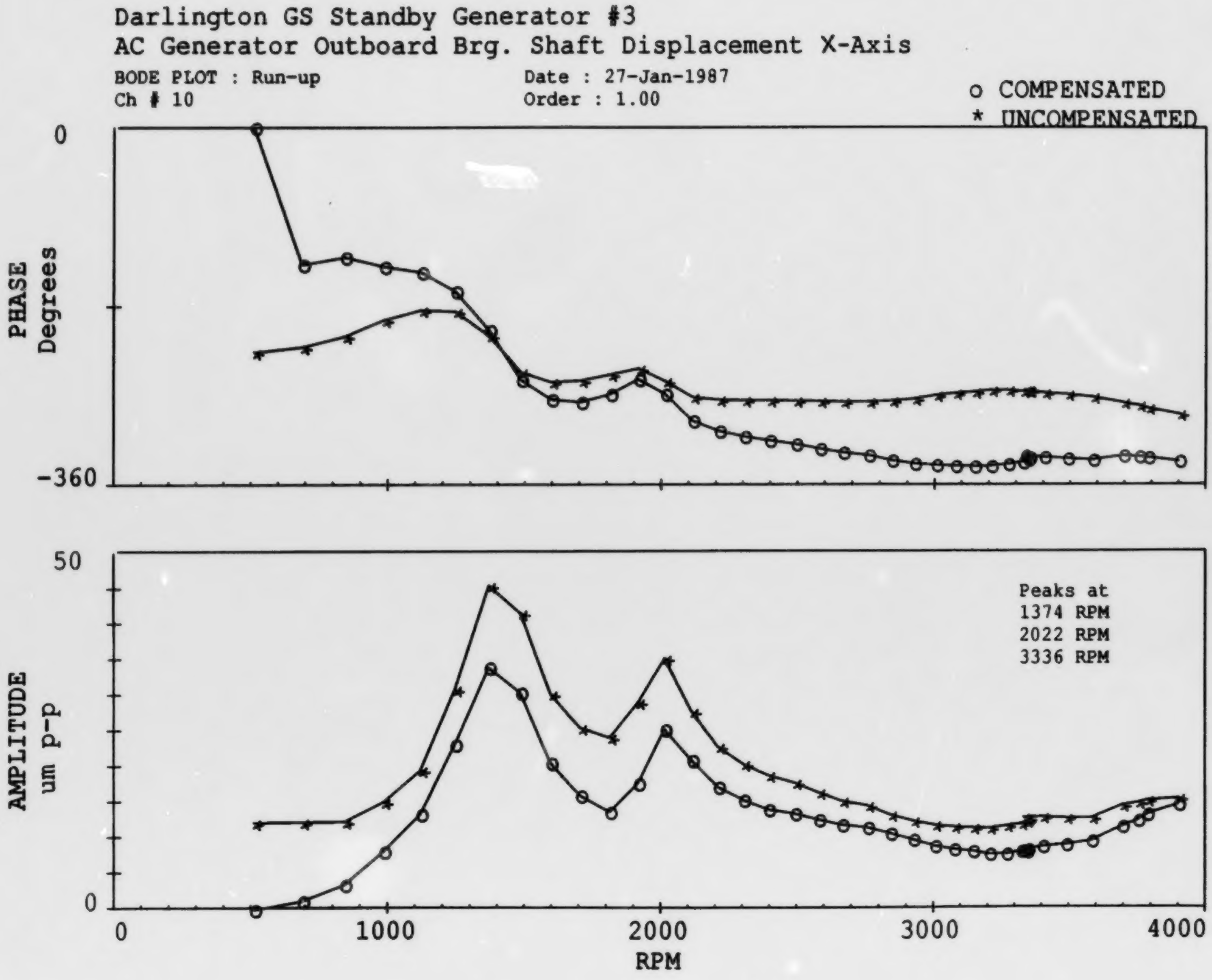


FIGURE 114



Darlington GS Standby Generator #3
AC Generator Outboard Brg. Shaft Displacement Y-Axis
BODE PLOT : Run-up
Ch # 9
Date : 27-Jan-1987
Order : 1.00

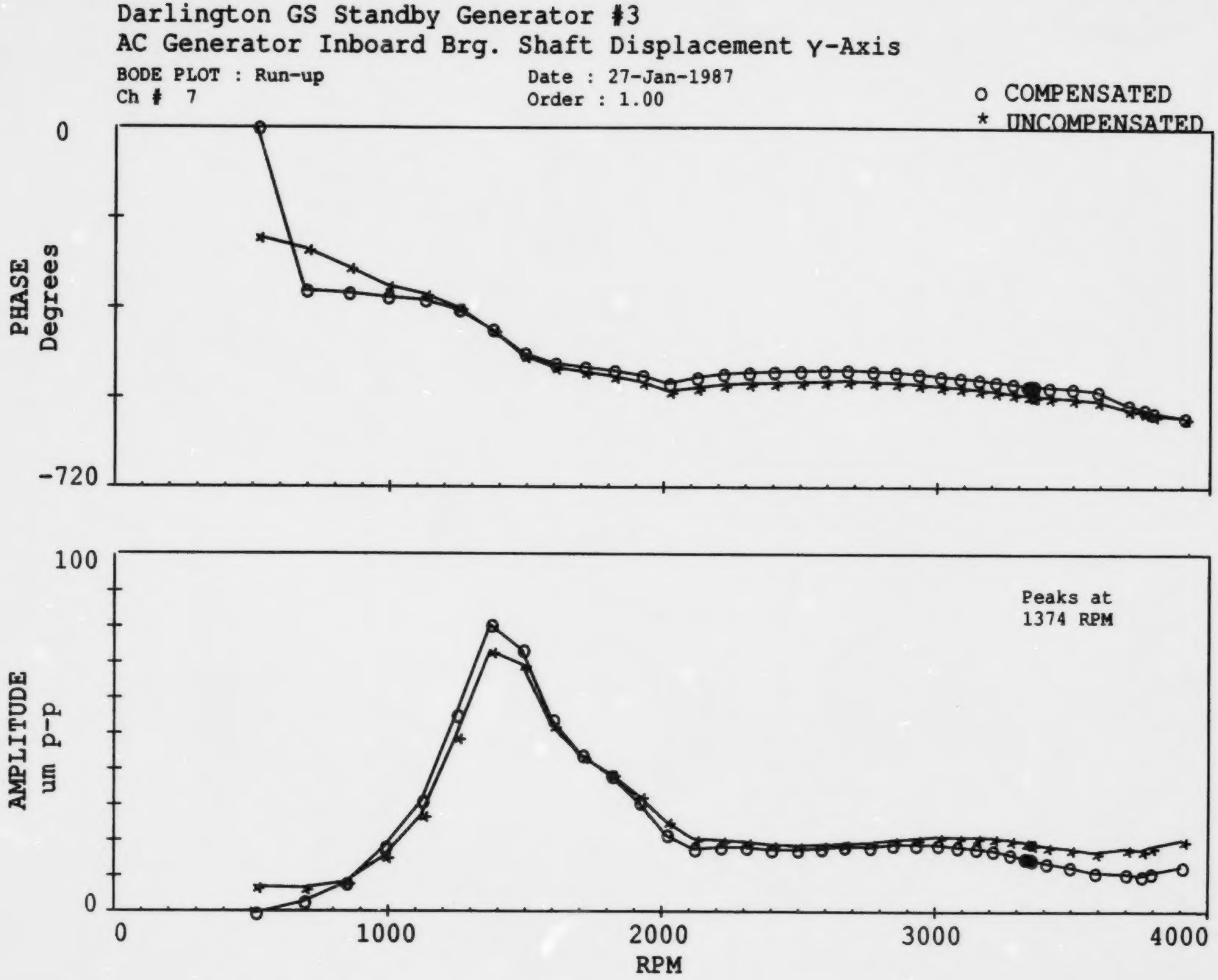
FIGURE 115


Darlington GS Standby Generator #3
AC Generator Outboard Brg. Shaft Displacement X-Axis

BODE PLOT : Run-up
Ch # 10

Date : 27-Jan-1987
Order : 1.00

FIGURE 116



Darlington GS Standby Generator #3
AC Generator Inboard Brg. Shaft Displacement Y-Axis

BODE PLOT : Run-up
Ch # 7

Date : 27-Jan-1987
Order : 1.00

FIGURE 117

Darlington GS Standby Generator #3
AC Generator Inboard Brg. Shaft Displacement X-Axis

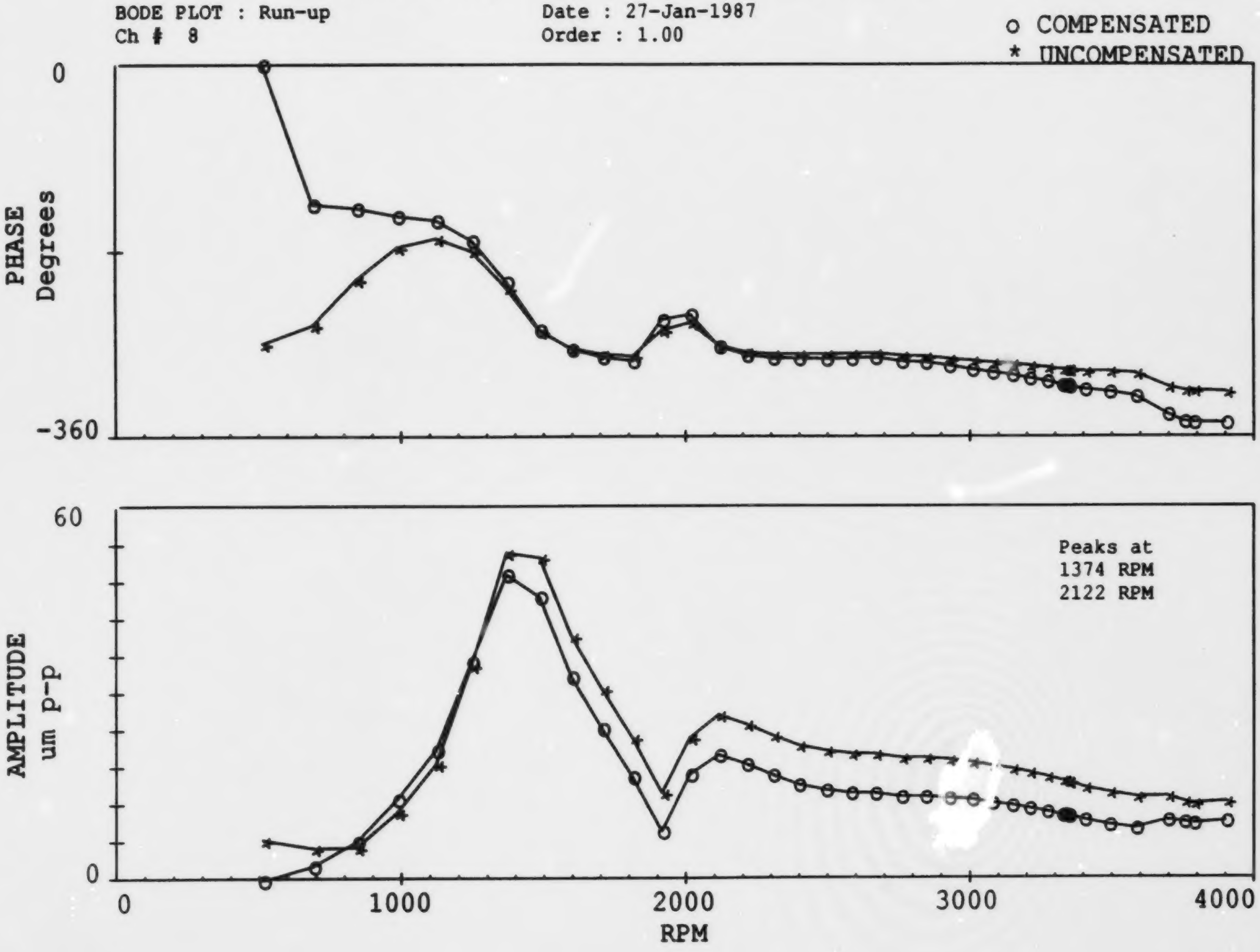


FIGURE 118

Darlington GS Standby Generator #3
Turbine Inboard Brg. Casing Velocity X-Axis
BODE PLOT : Run-up
Ch # 2
Date : 27-Jan-1987
Order : 1.00

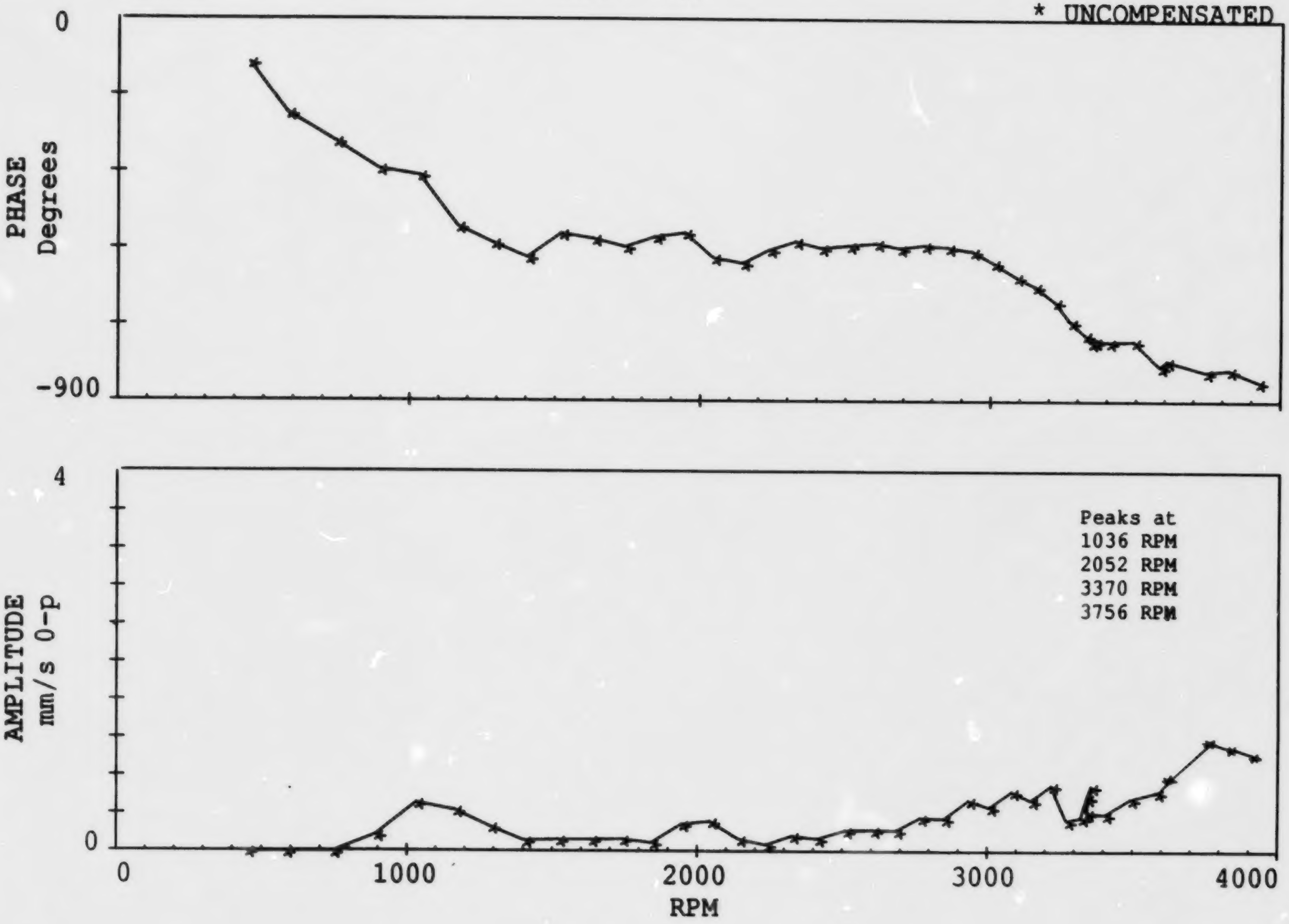


FIGURE 119

Darlington GS Standby Generator #3
Turbine Inboard Brg. Casing Velocity Y-Axis
BODE PLOT : Run-up
Ch # 1
Date : 27-Jan-1987
Order : 1.00

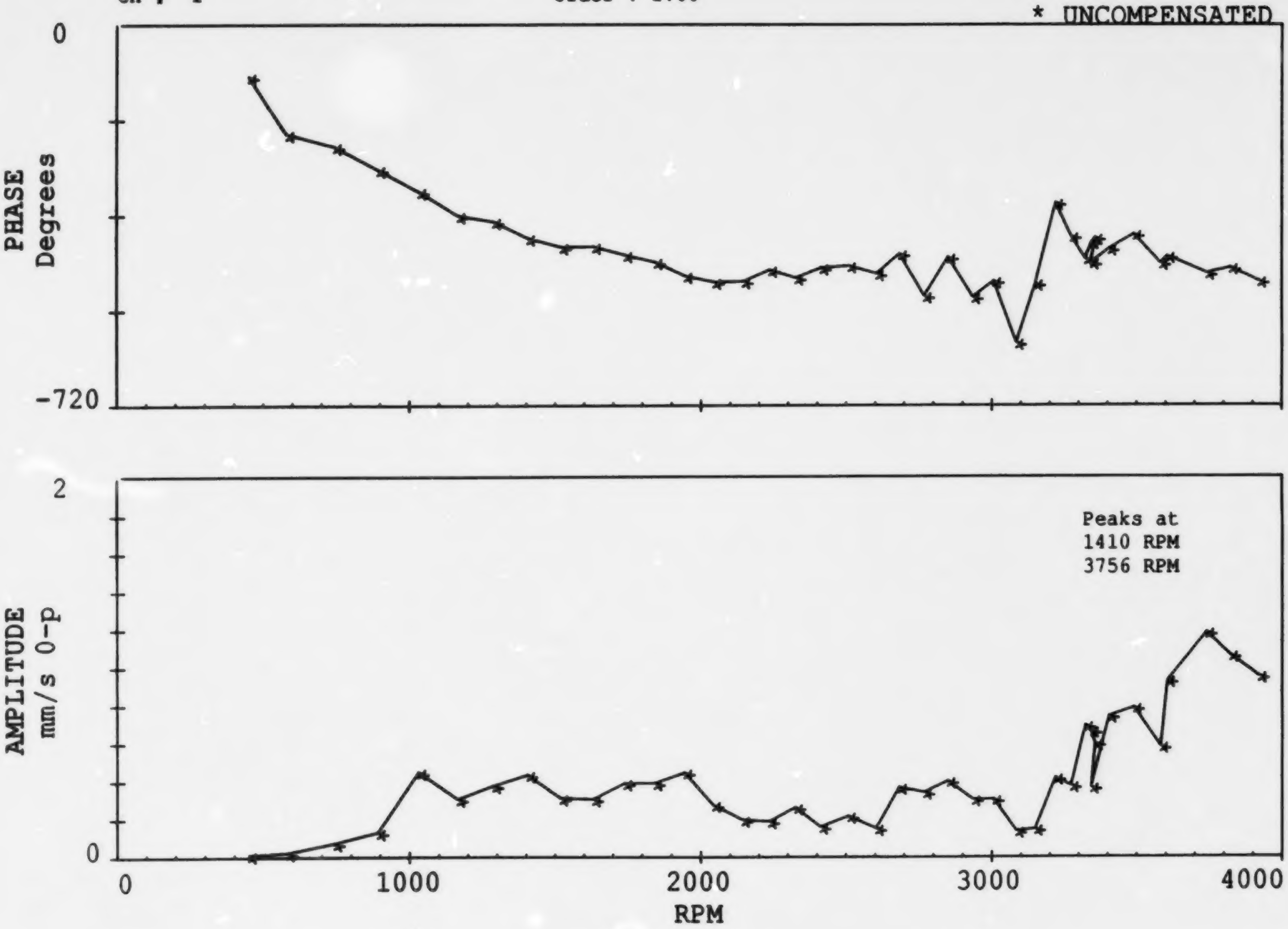
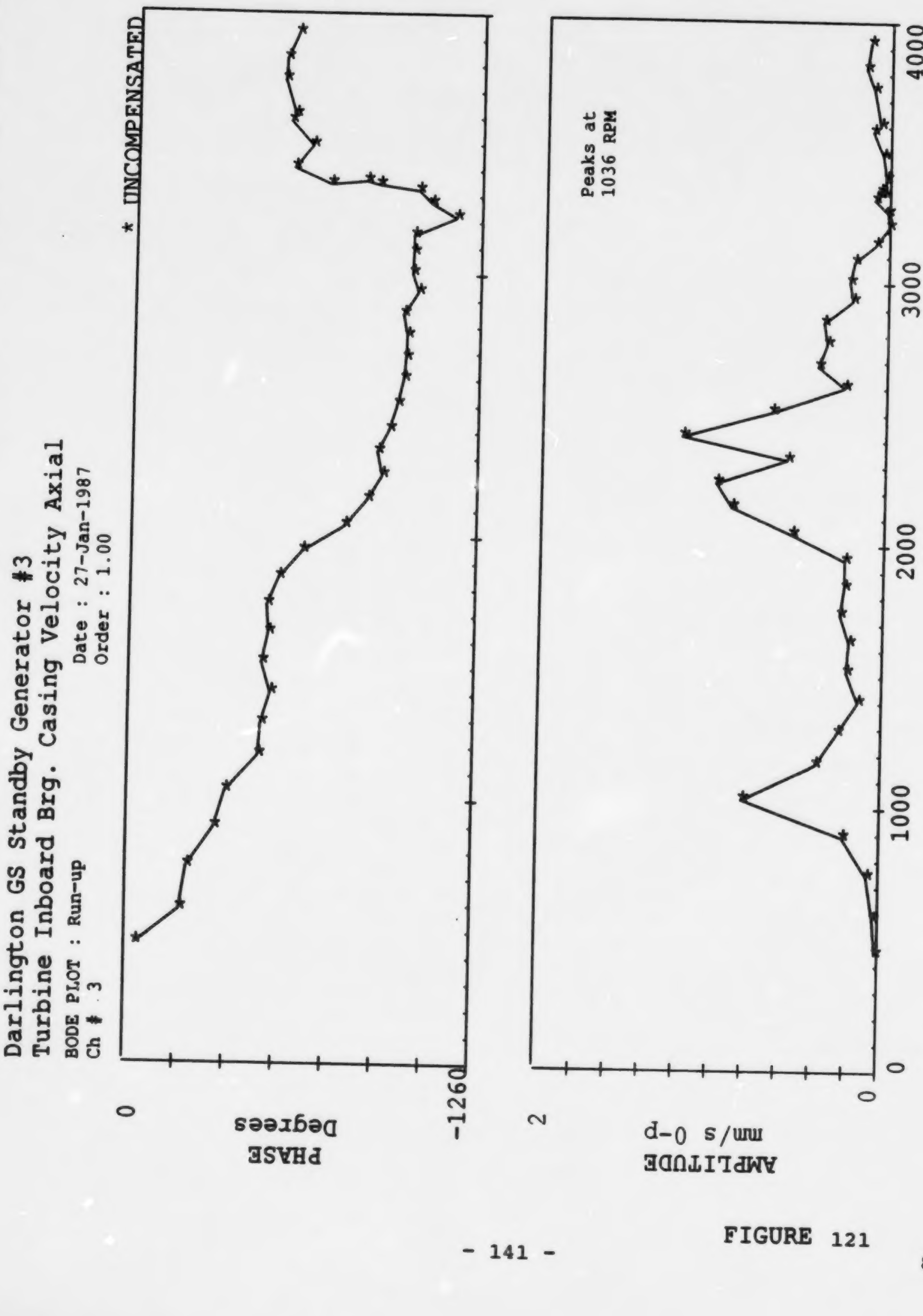


FIGURE 120



Darlington GS Standby Generator #3
Turbine Inboard Brg. Casing Velocity Axial

BODE PLOT : Run-up
Ch # 3

Date : 27-Jan-1987
Order : 1.00

FIGURE 121

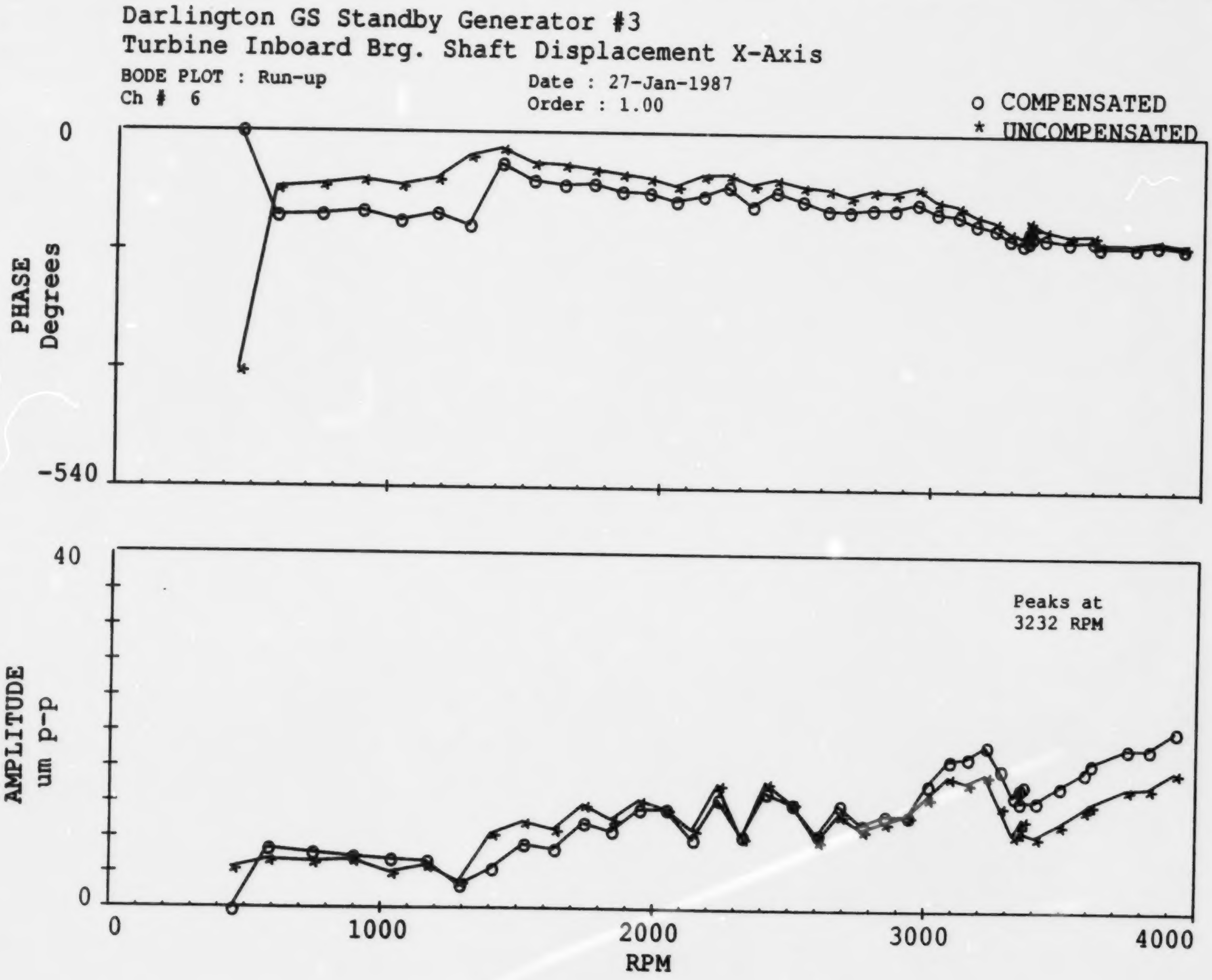

Darlington GS Standby Generator #3
Turbine Inboard Brg. Shaft Displacement X-Axis
BODE PLOT : Run-up
Ch # 6
Date : 27-Jan-1987
Order : 1.00
o COMPENSATED
* UNCOMPENSATED
PHASE
Degrees
0
-540
AMPLITUDE
um p-p
40
0
Peaks at
3232 RPM
0
1000
2000
3000
4000
RPM

FIGURE 122

Darlington GS Standby Generator #3
Turbine Inboard Brg. Shaft Displacement Y-Axis

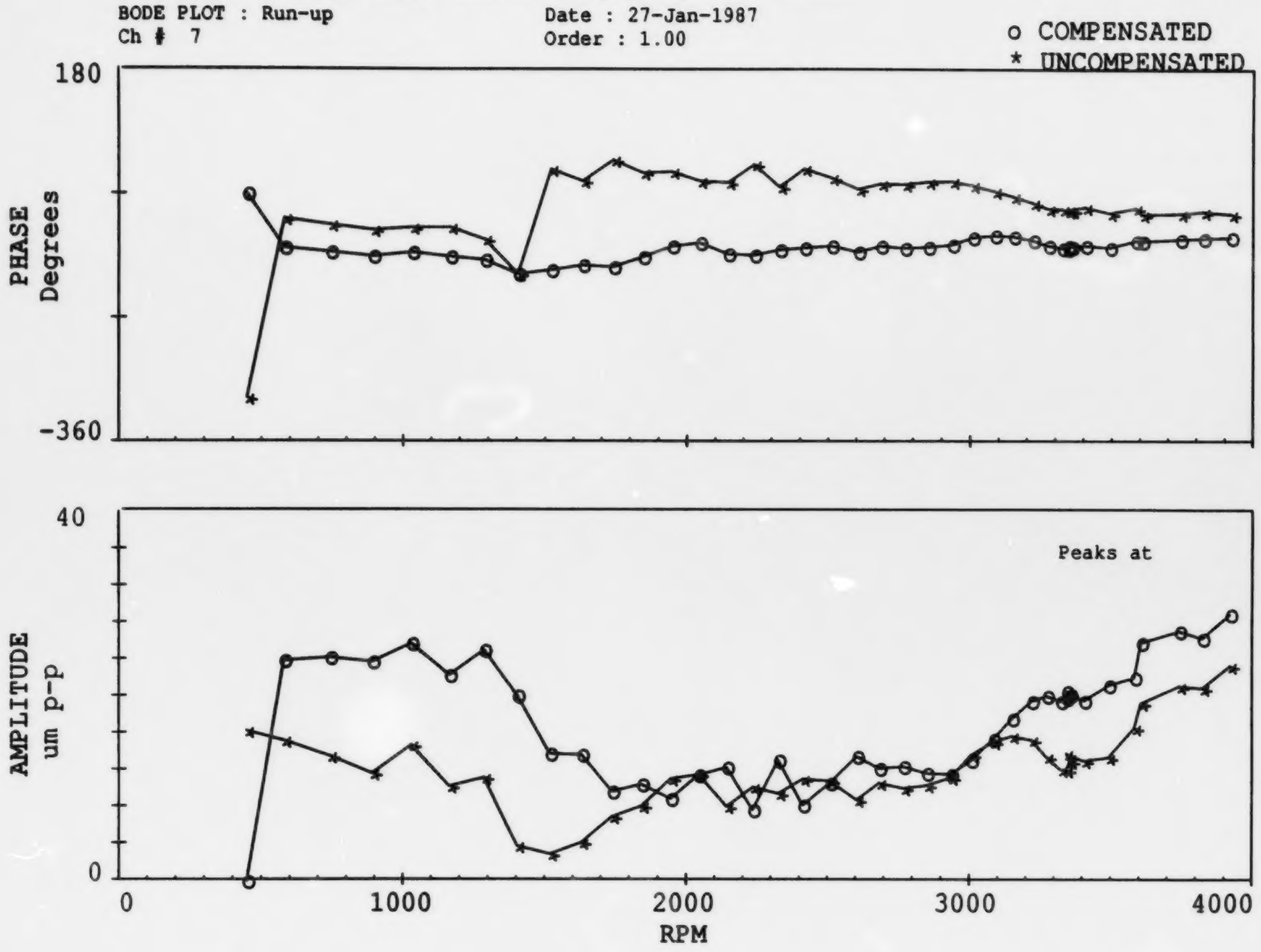
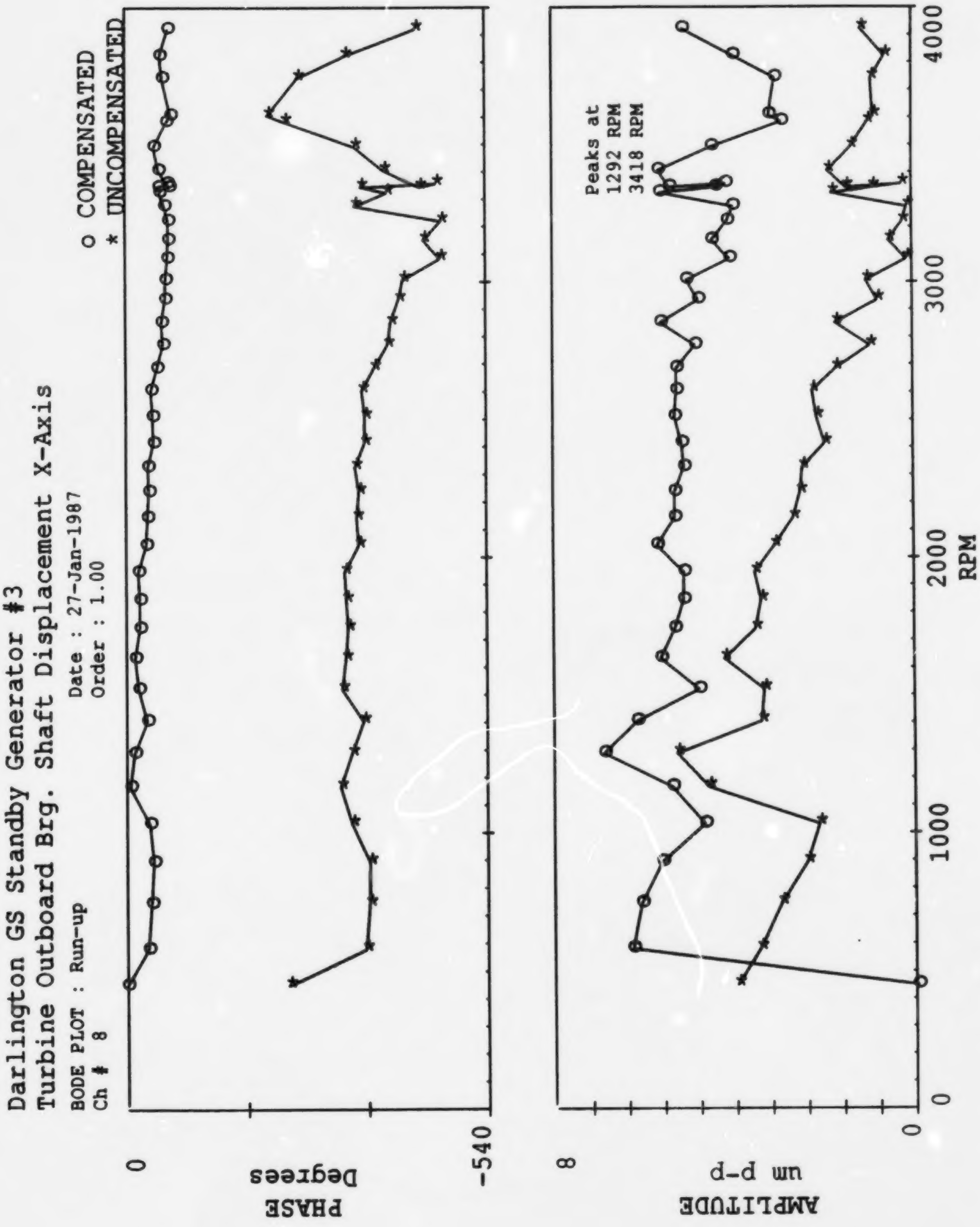


FIGURE 123



Darlington GS Standby Generator #3
Turbine Outboard Brg. Shaft Displacement X-Axis
BODE PLOT : Run-up
Ch # 8
Date : 27-Jan-1987
Order : 1.00
o COMPENSATED
* UNCOMPENSATED
PHASE
Degrees
0
-540
AMPLITUDE
um p-p
8
0
Peaks at
1292 RPM
3418 RPM
0
1000
2000
3000
4000
RPM

FIGURE 124

Darlington GS Standby Generator #3
Turbine Outboard Brg. Shaft Displacement Y-Axis

BODE PLOT : Run-up
Ch # 9

Date : 27-Jan-1987
Order : 1.00

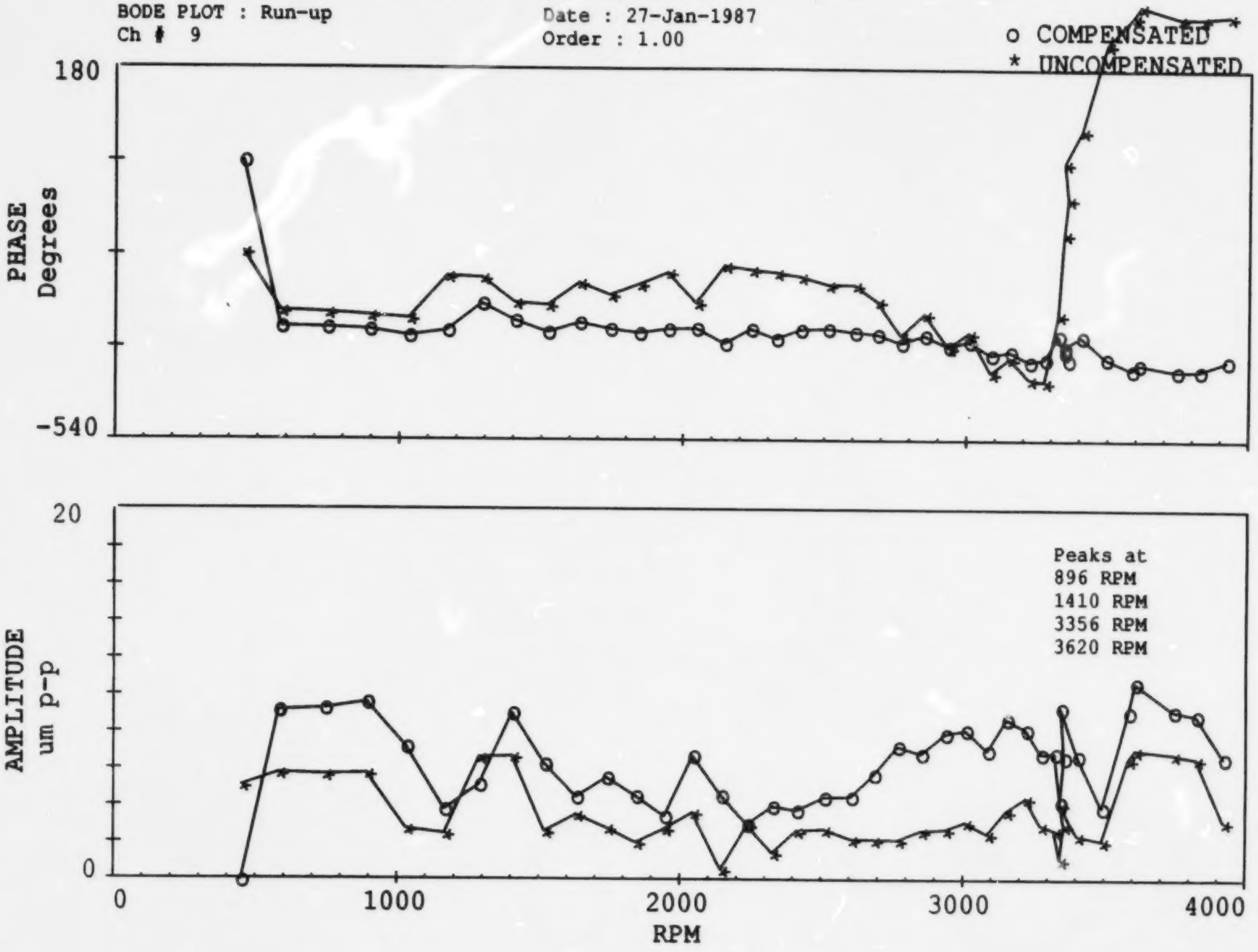


FIGURE 125

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 2 Outboard Brg. Casing Velocity X-Axis

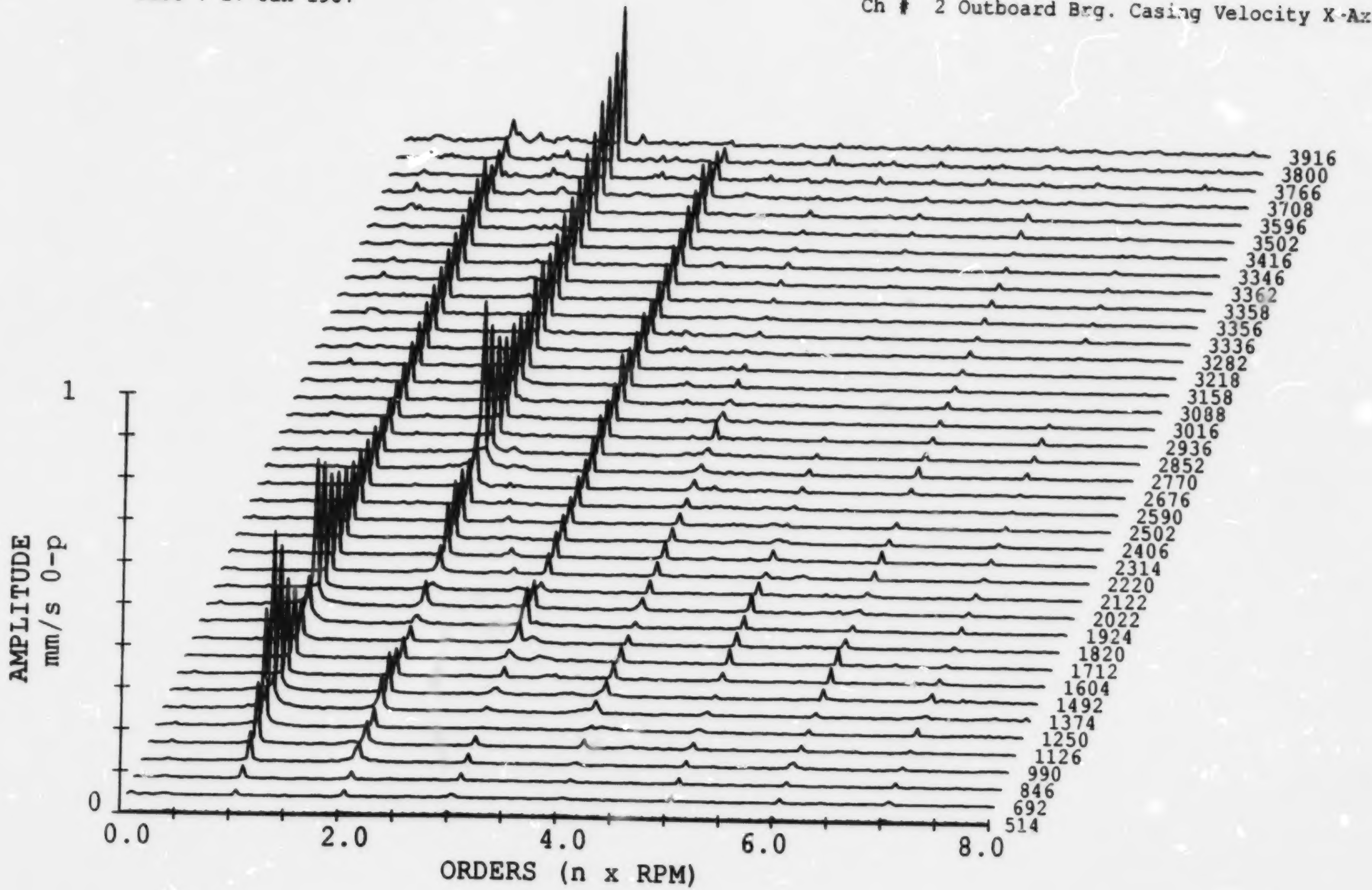


FIGURE 126

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 1 Outboard Brg. Casing Velocity Y-Axis

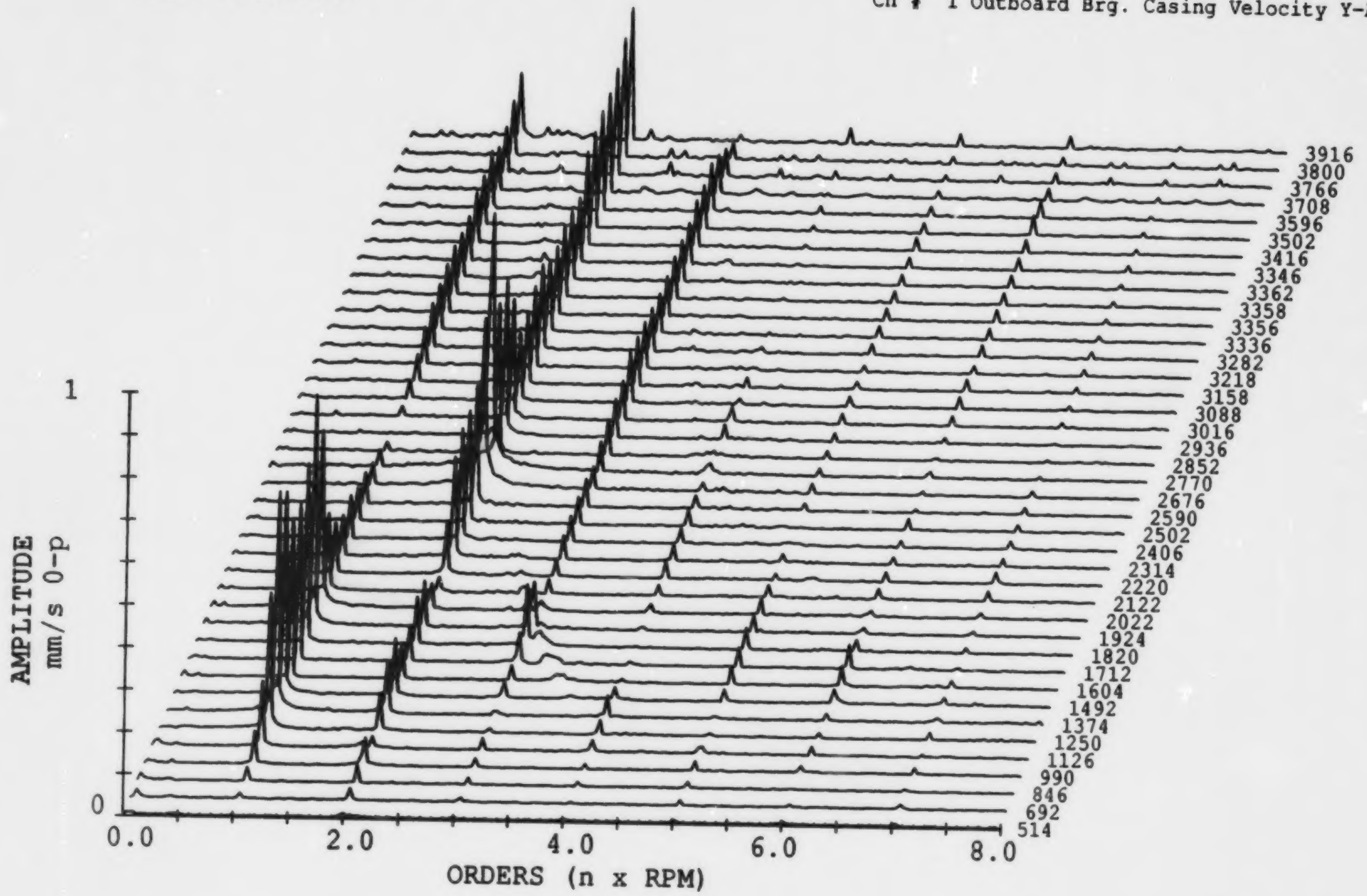


FIGURE 127

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 3 Outboard Brg. Casing Velocity Axial

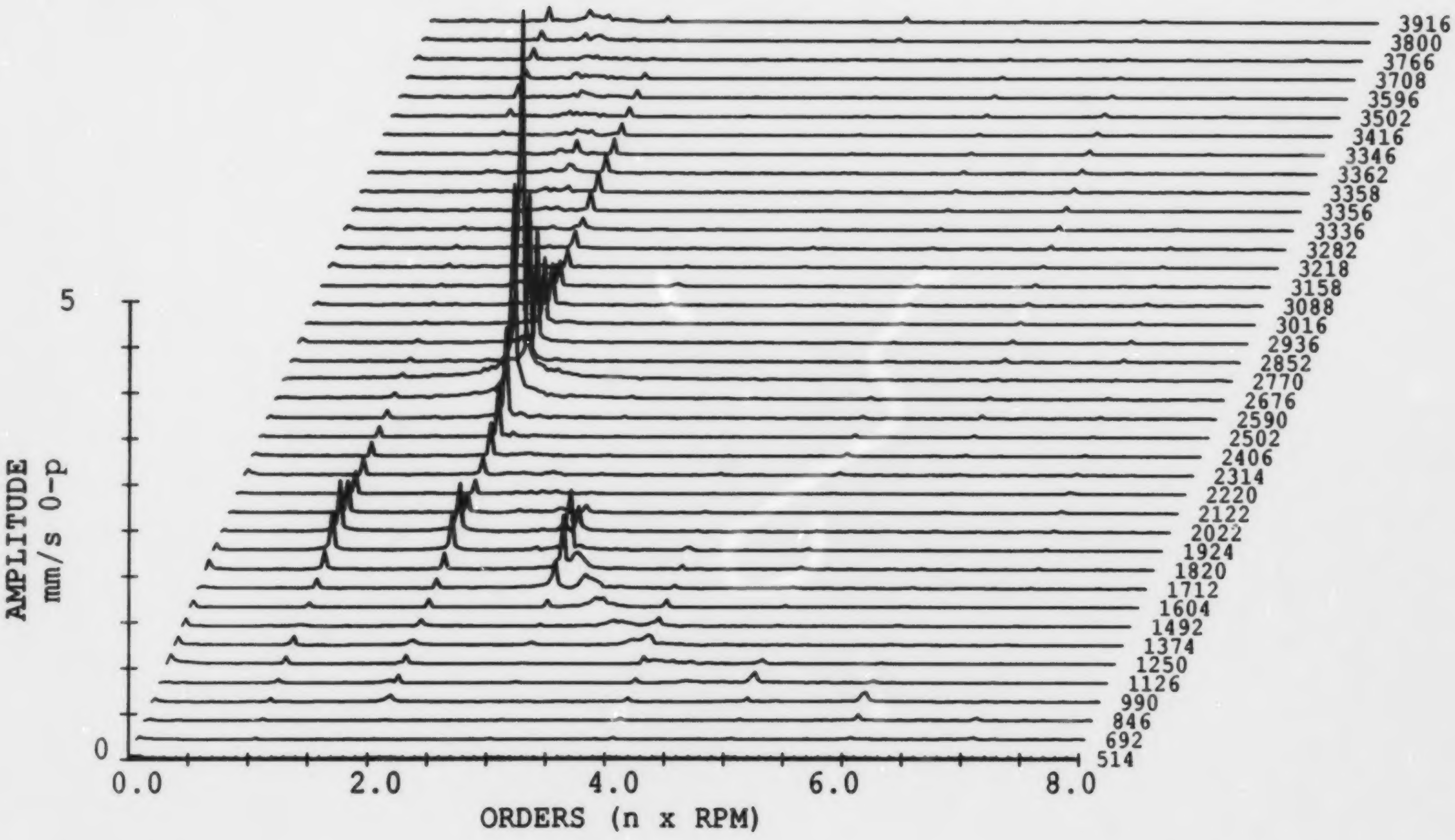


FIGURE 128

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 5 Inboard Brg. Casing Velocity X-Axis

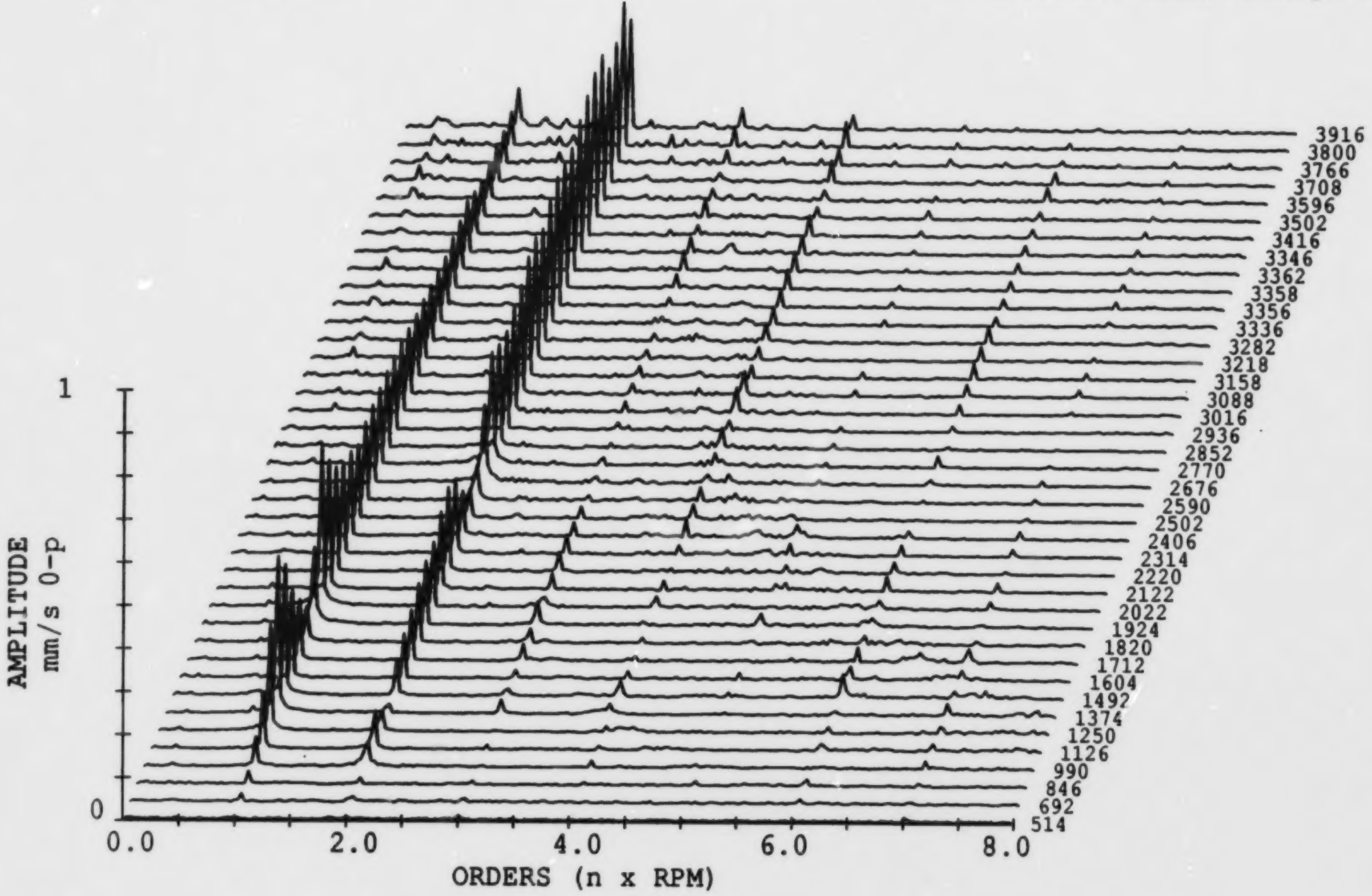


FIGURE 129

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 4 Inboard Brg. Casing Velocity Y-Axis

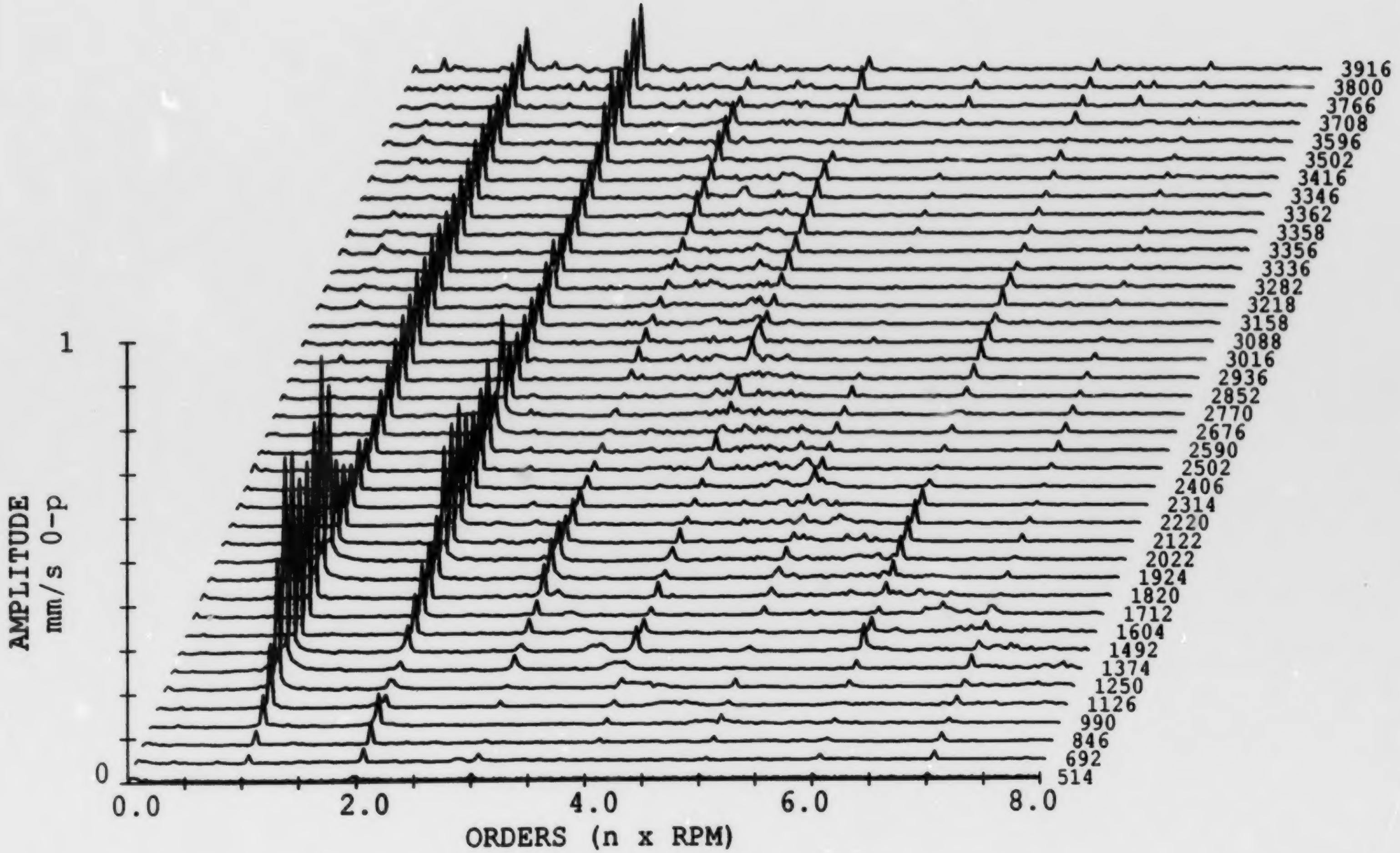


FIGURE 130

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 6 Inboard Brg. Casing Velocity Axial

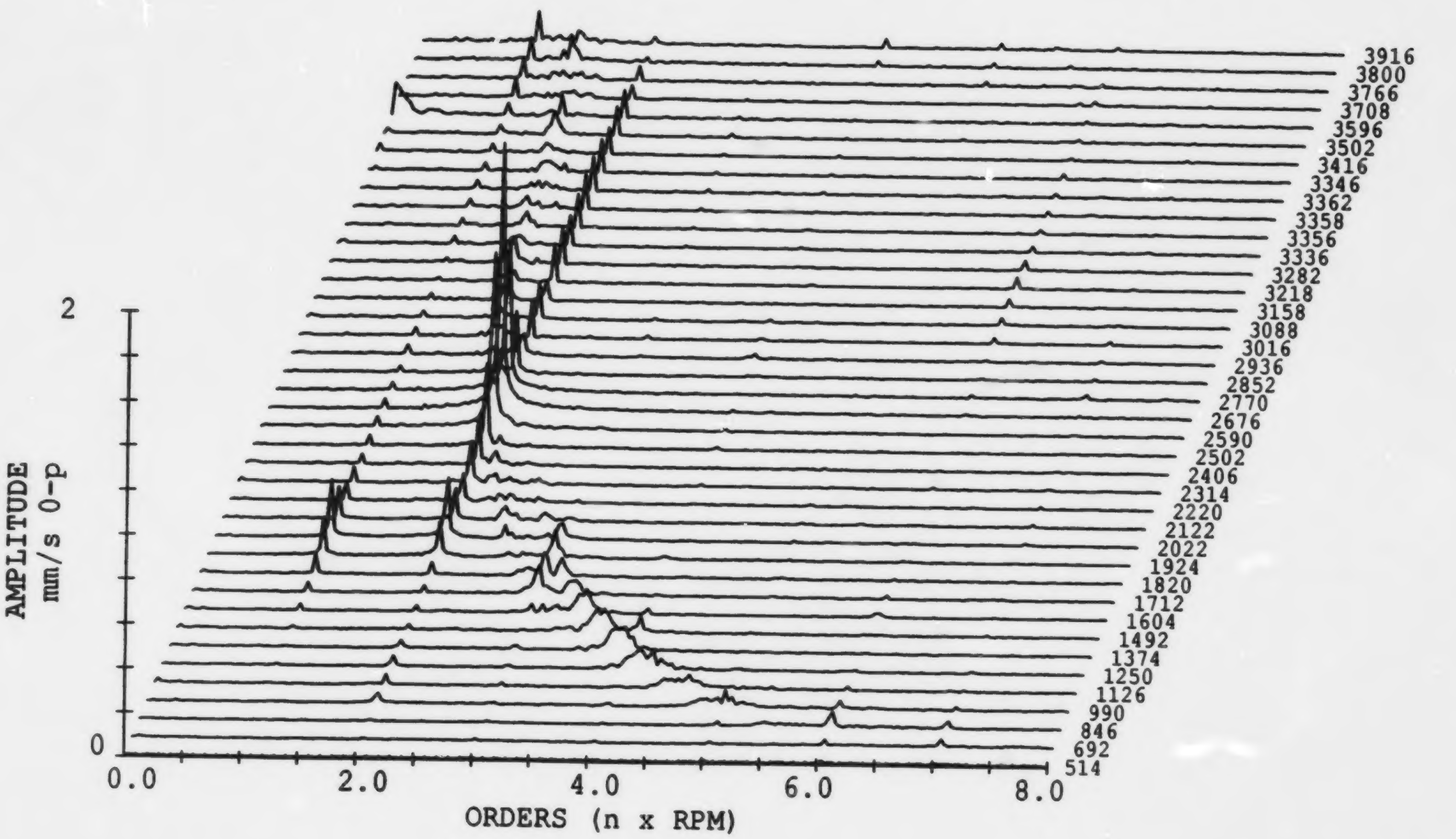


FIGURE 131

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 9 Outboard Brg. Shaft Displacement Y-Axis

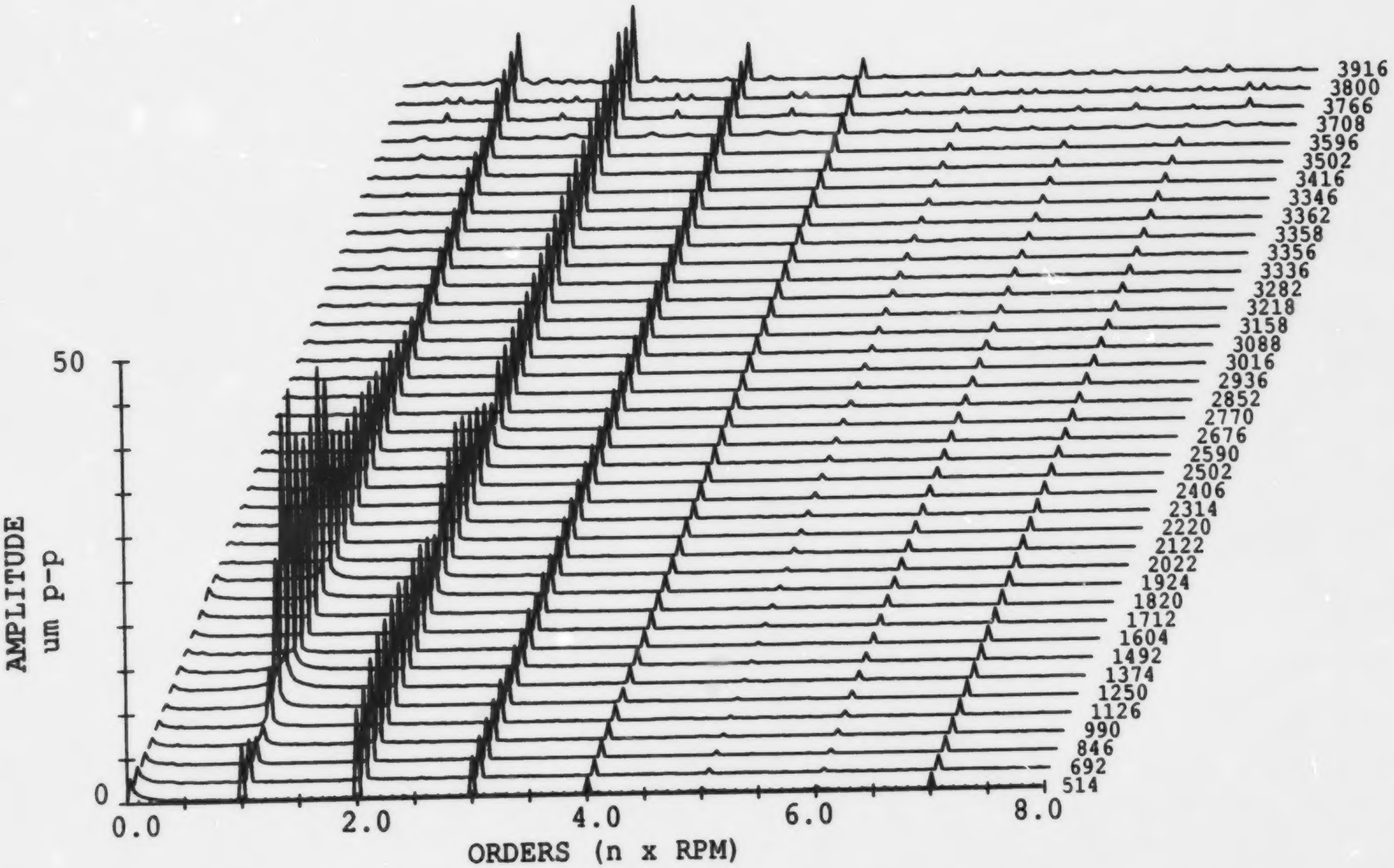


FIGURE 132

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 10 Outboard Brg. Shaft Displacement X-Axis

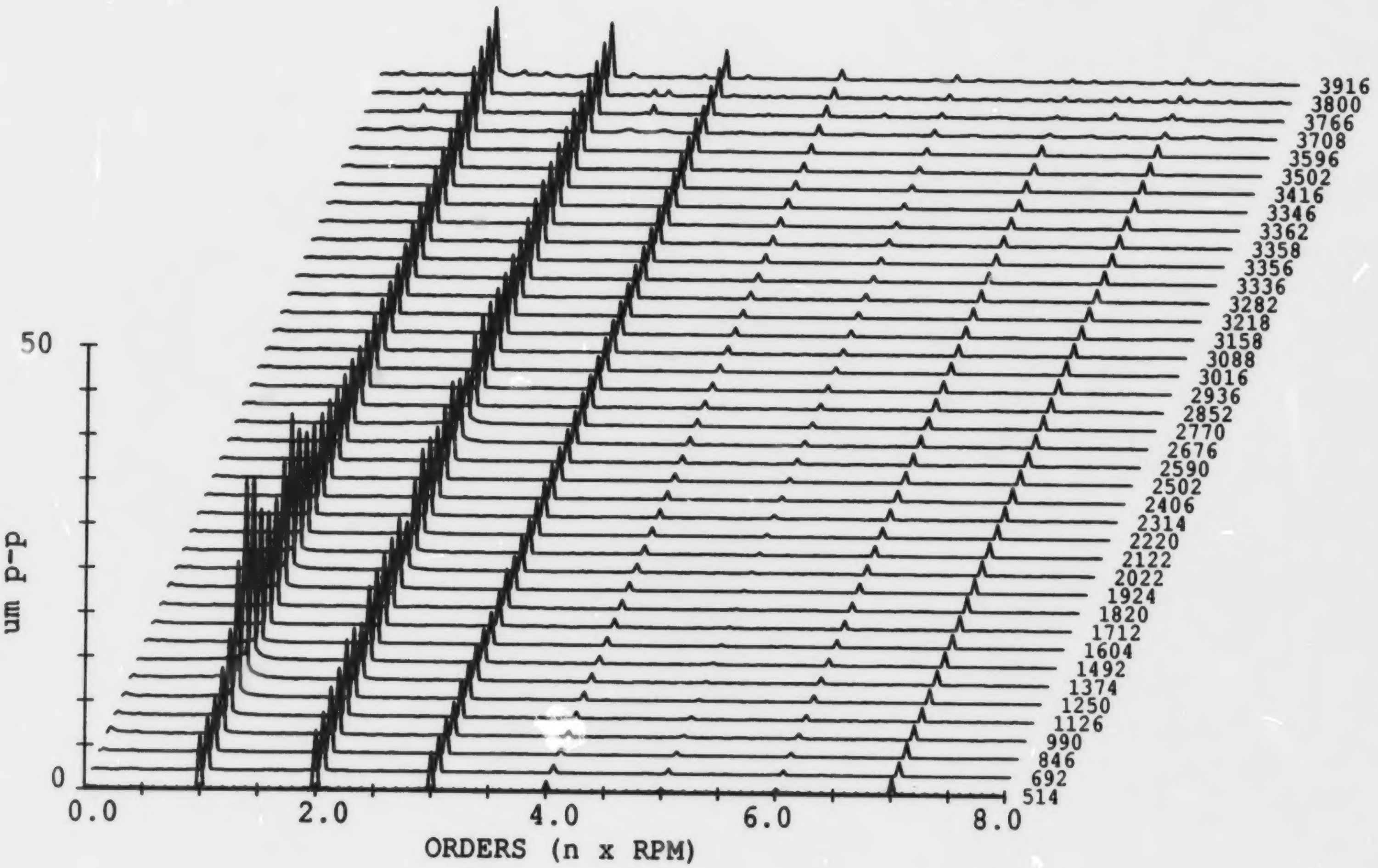


FIGURE 133

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 7 Inboard Brg. Shaft Displacement Y-Axis

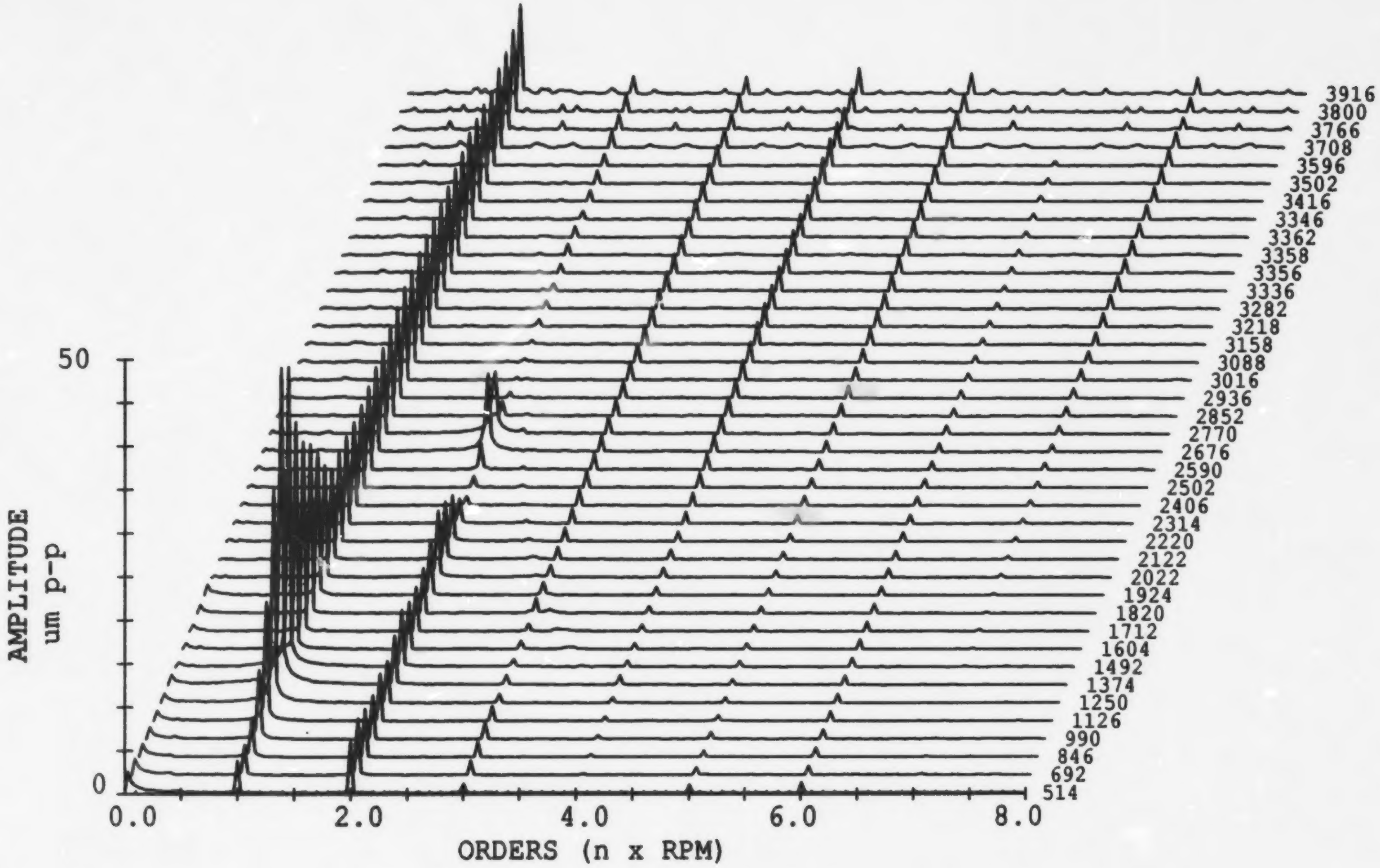


FIGURE 134

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 8 Inboard Brg. Shaft Displacement X-Axis

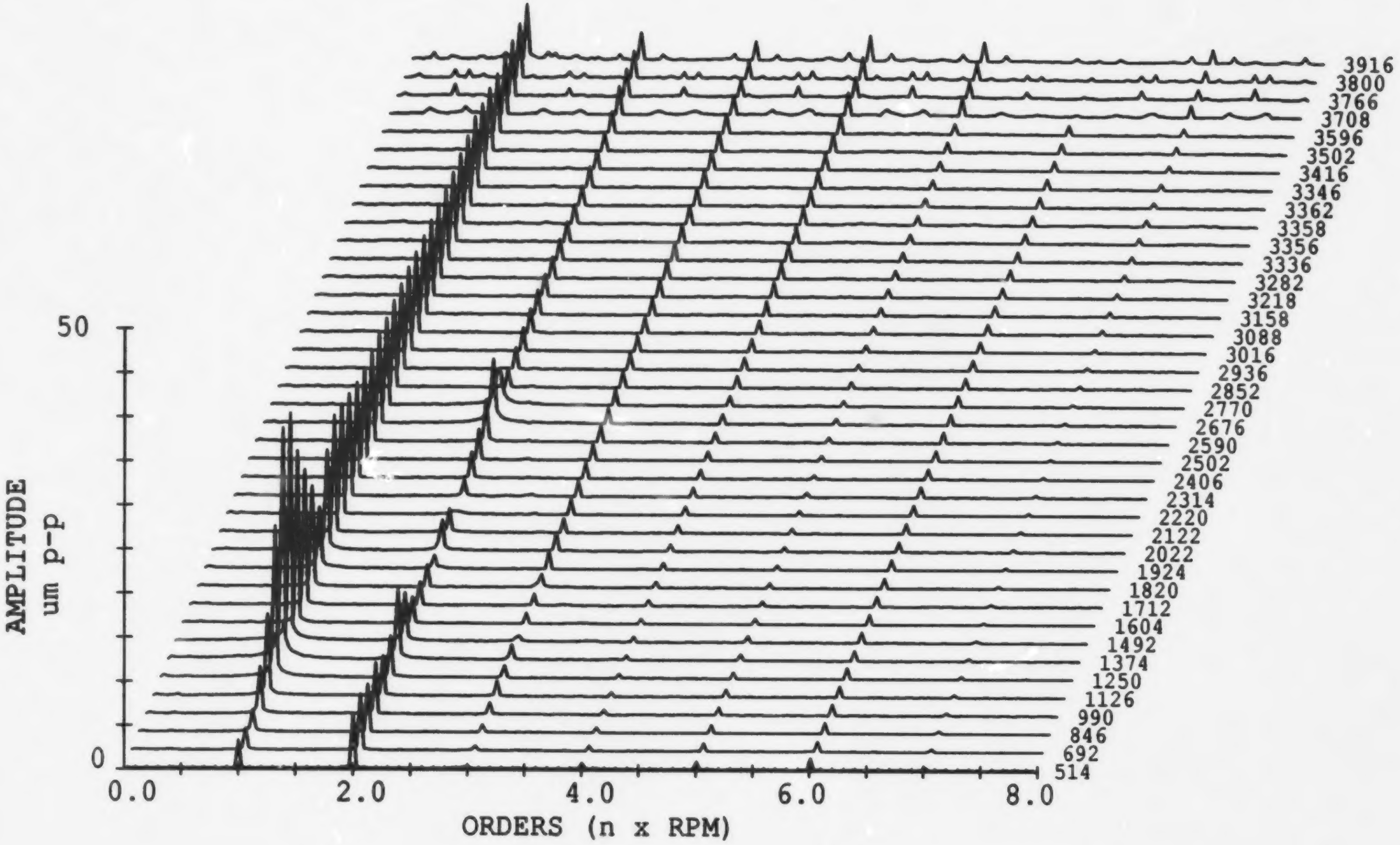


FIGURE 135

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 2 Inboard Brg. Casing Velocity X-Axis

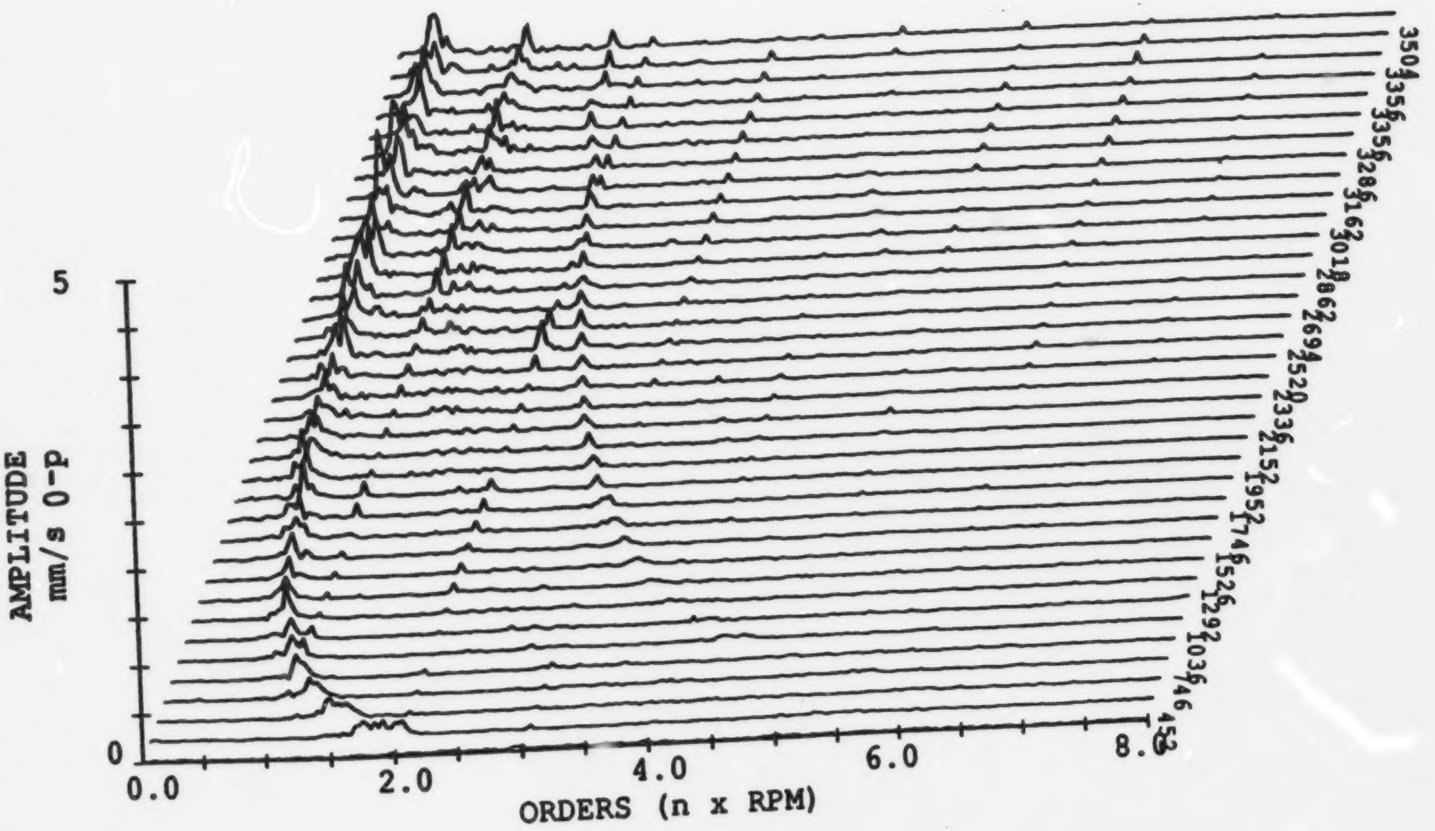


FIGURE 136 89-5

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 1 Inboard Brg. Casing Velocity Y-Axis

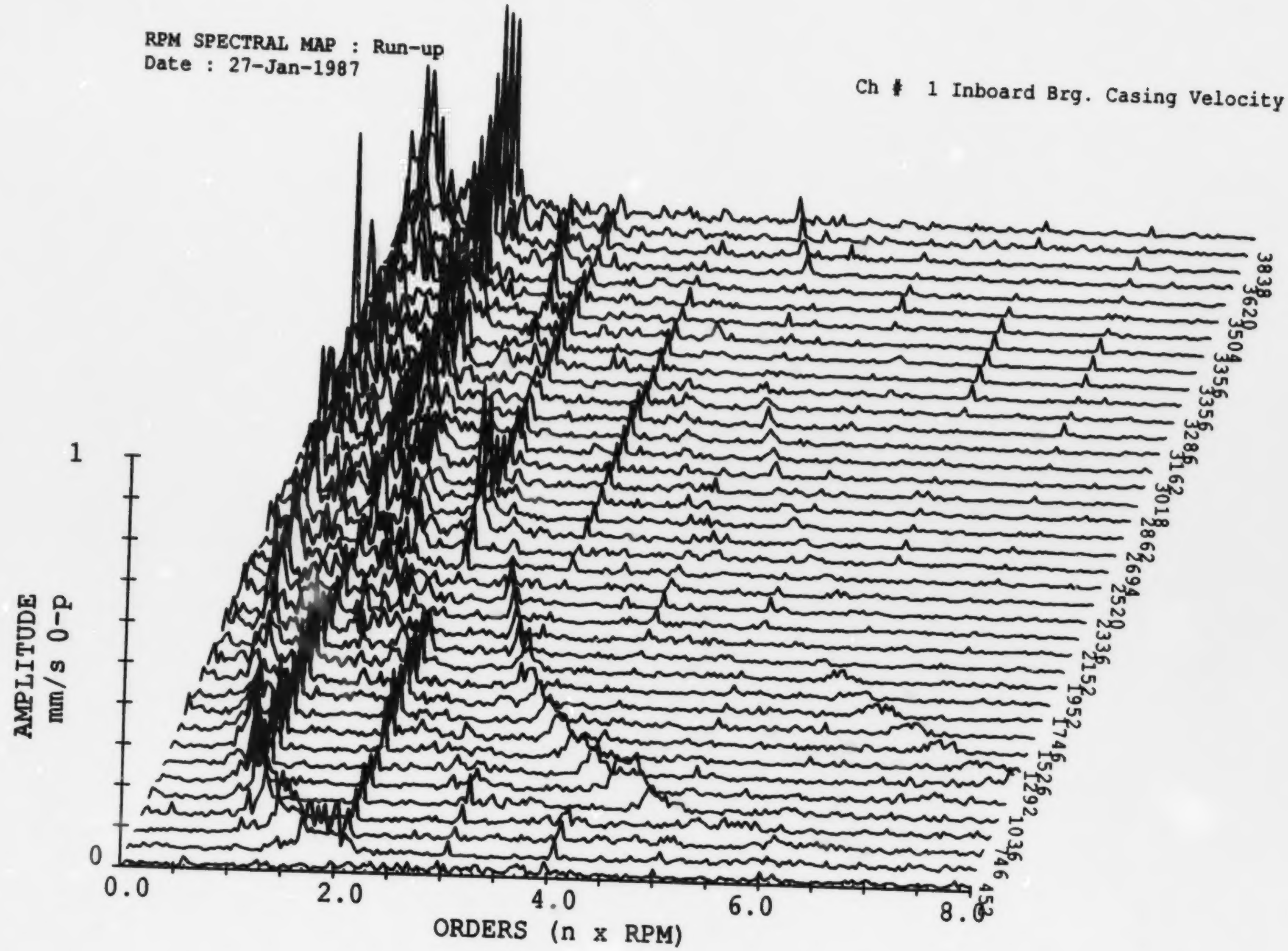


FIGURE 137

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 3 Inboard Brg. Casing Velocity Axial

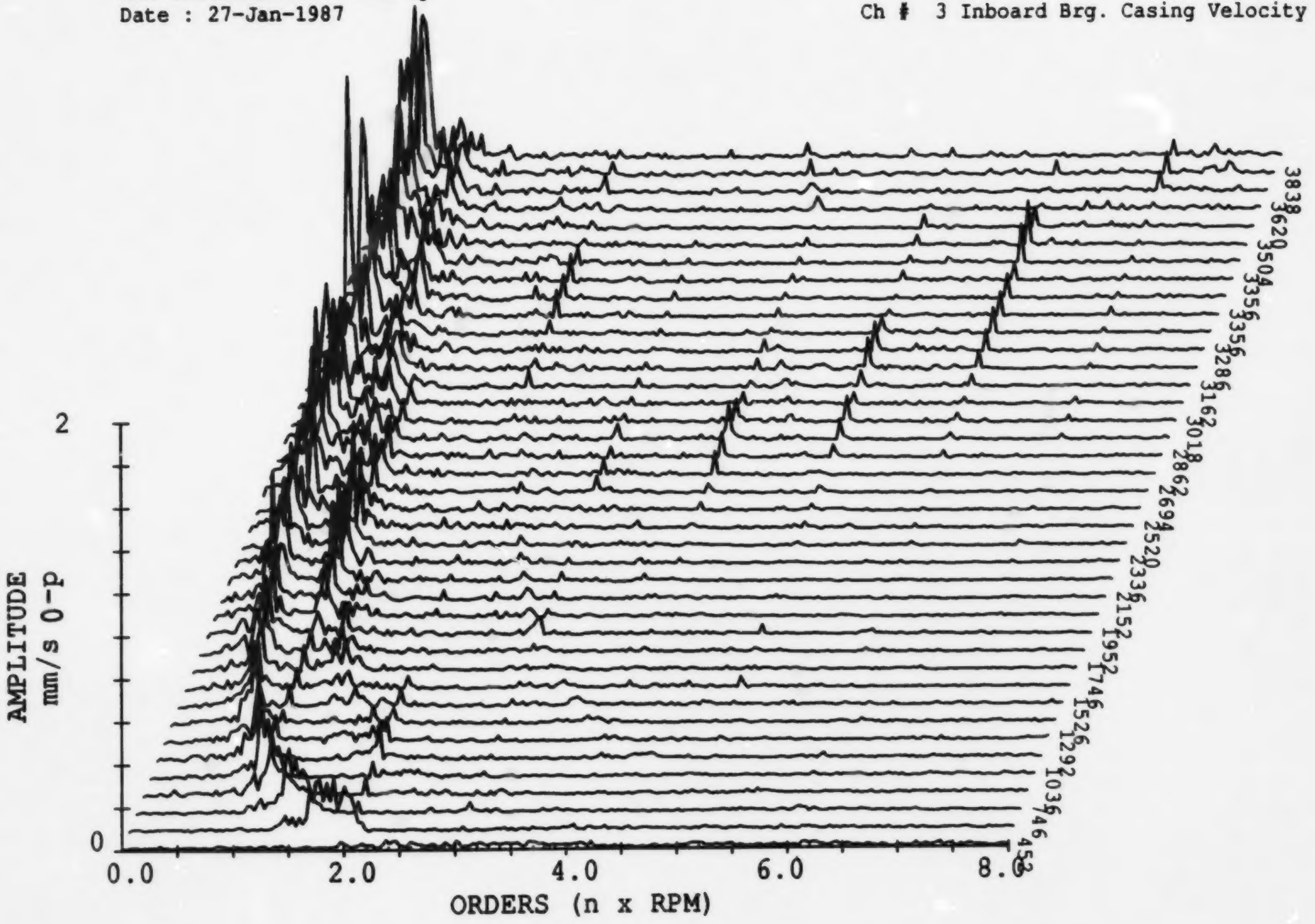


FIGURE 138

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 6 Inboard Brg. Shaft Displacement X-Axis

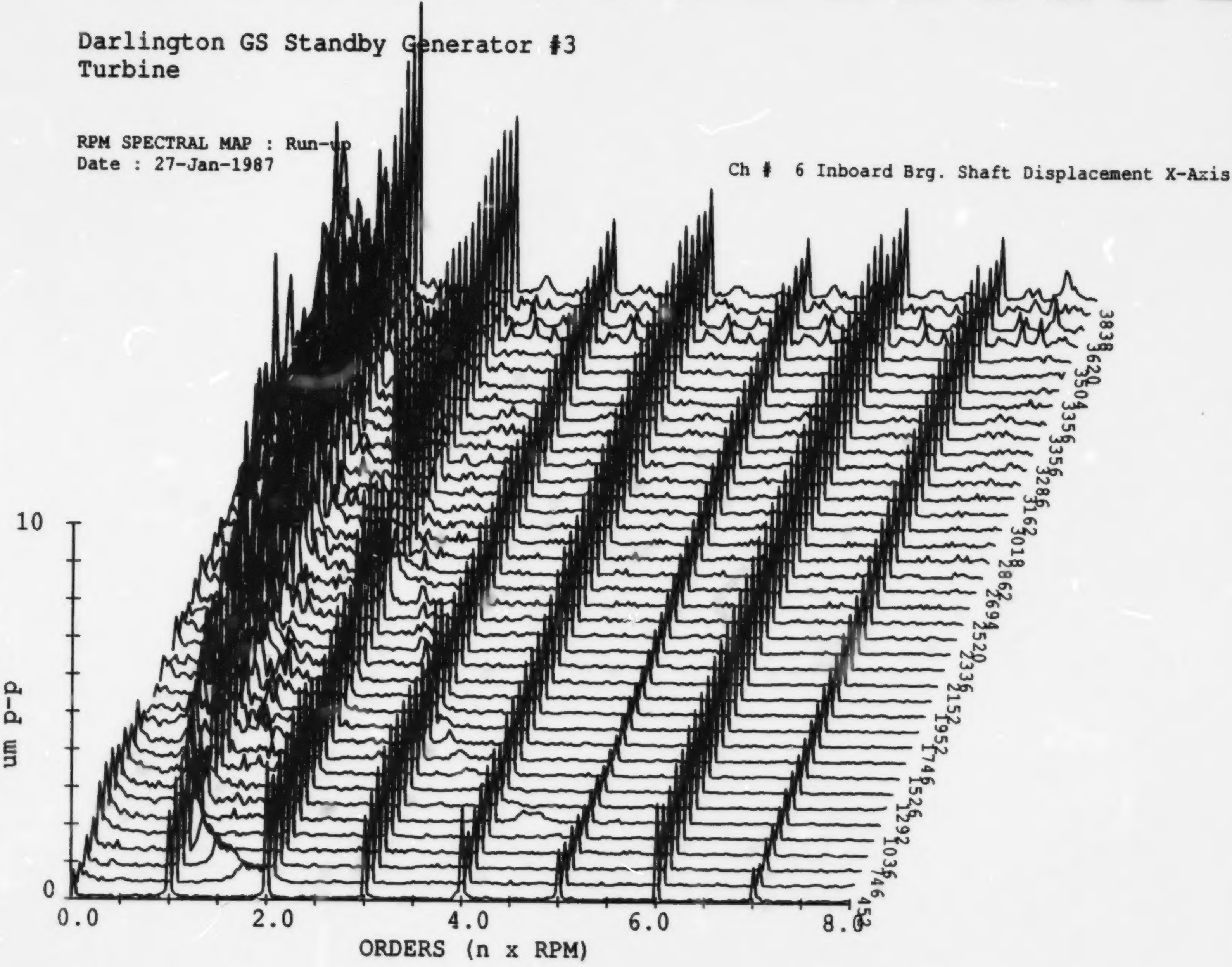


FIGURE 139

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 7 Inboard Brg. Shaft Displacement Y-Axis

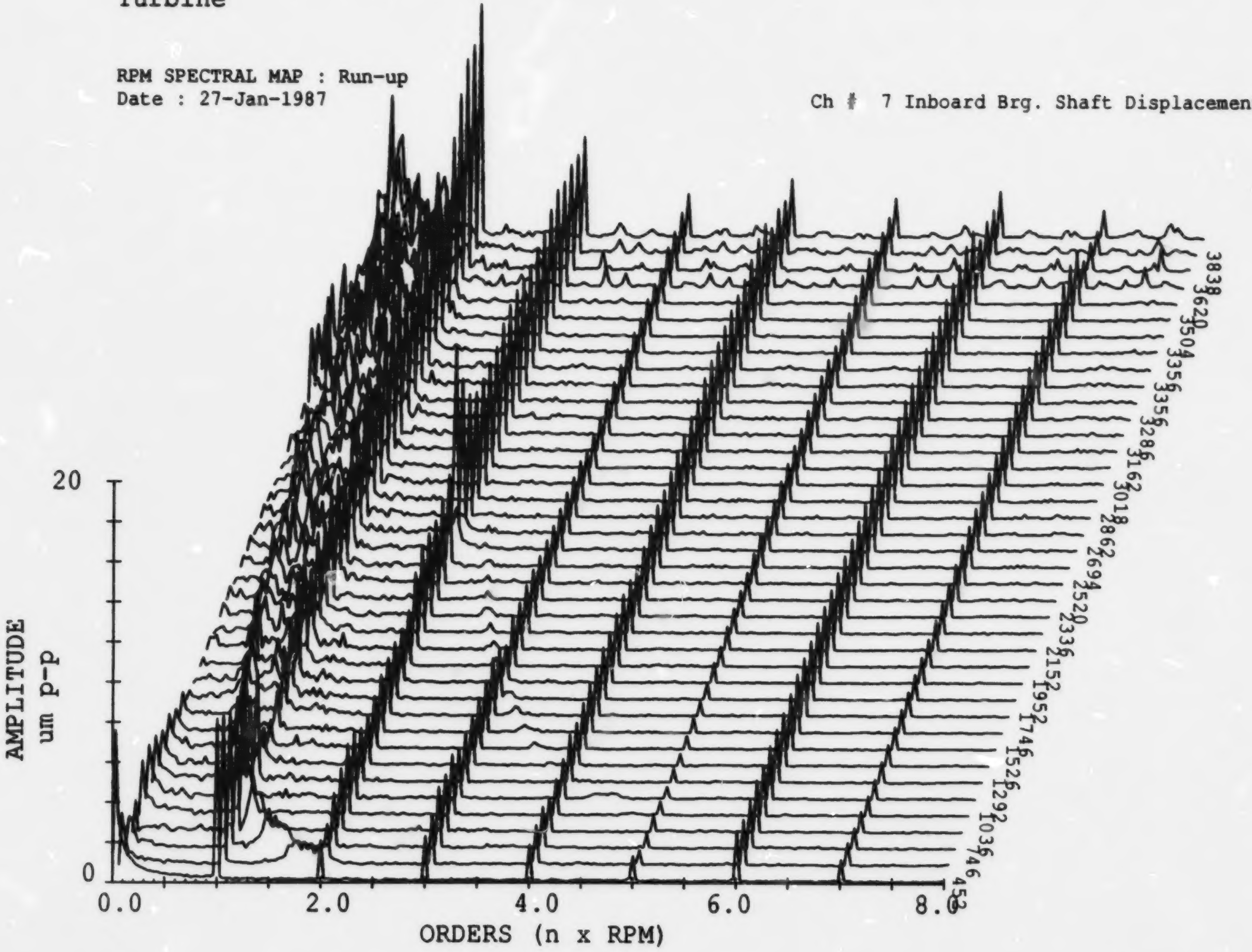


FIGURE 140

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-up
Date : 27-Jan-1987

Ch # 8 Outboard Brg. Shaft Displacement X-Axis

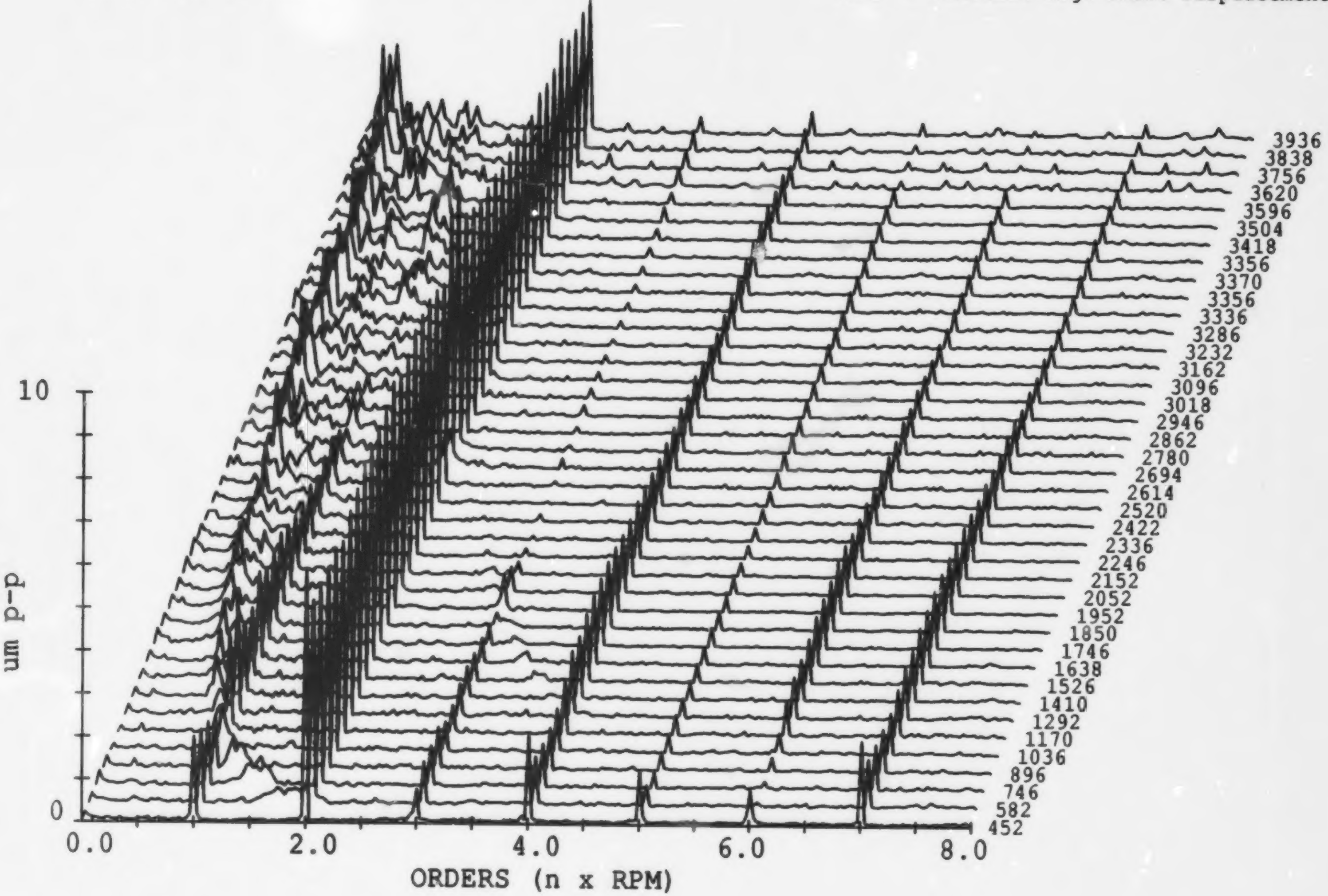


FIGURE 141

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-
Date : 27-Jan-1987

Ch # 9 Outboard Brg. Shaft Displacement Y-Axis

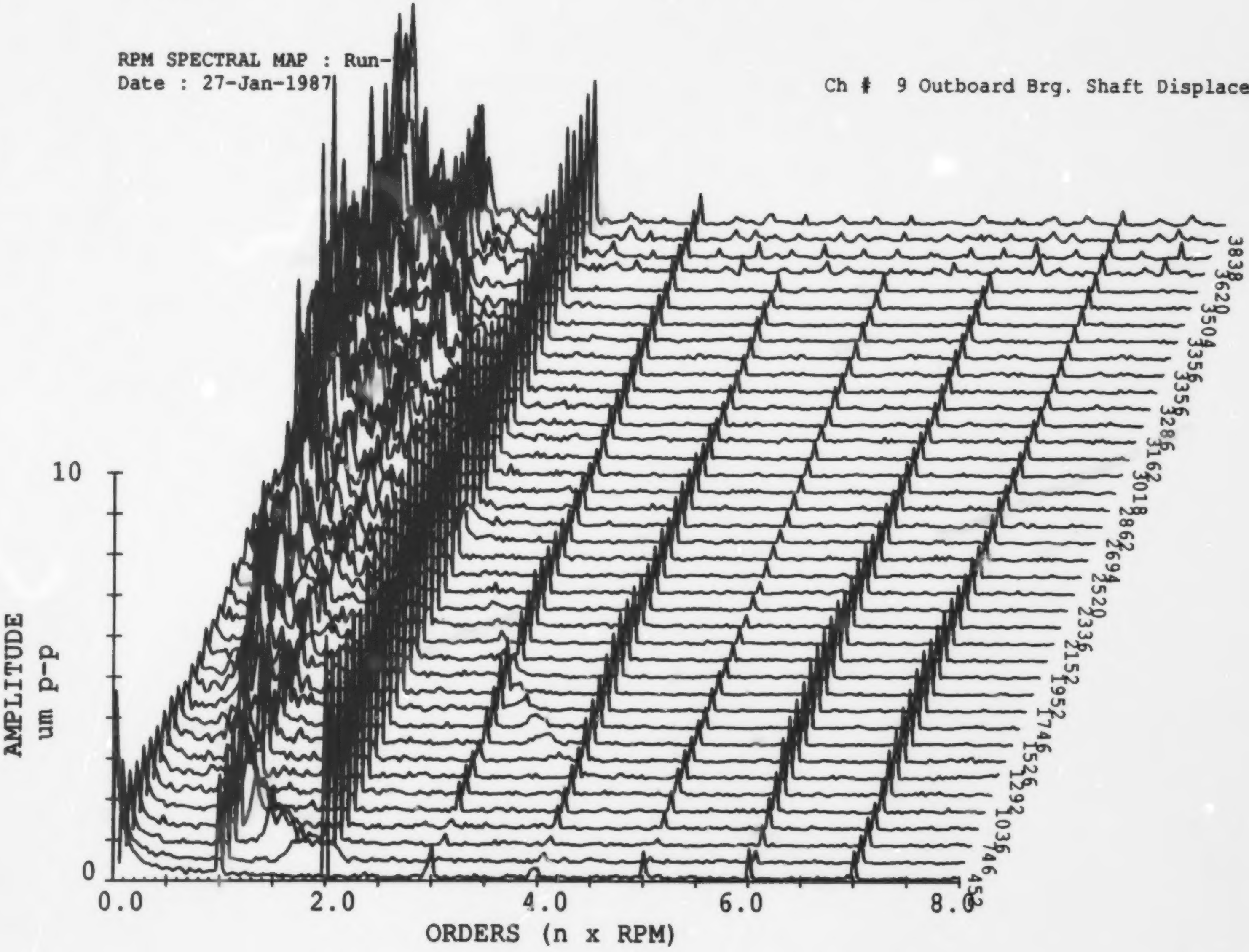


FIGURE 142

Darlington GS Standby Generator #3
AC Generator Outboard Brg. Casing Velocity X-Axis
BODE PLOT : Run-down
Ch # 2
Date : 27-Jan-1987
Order : 1.00

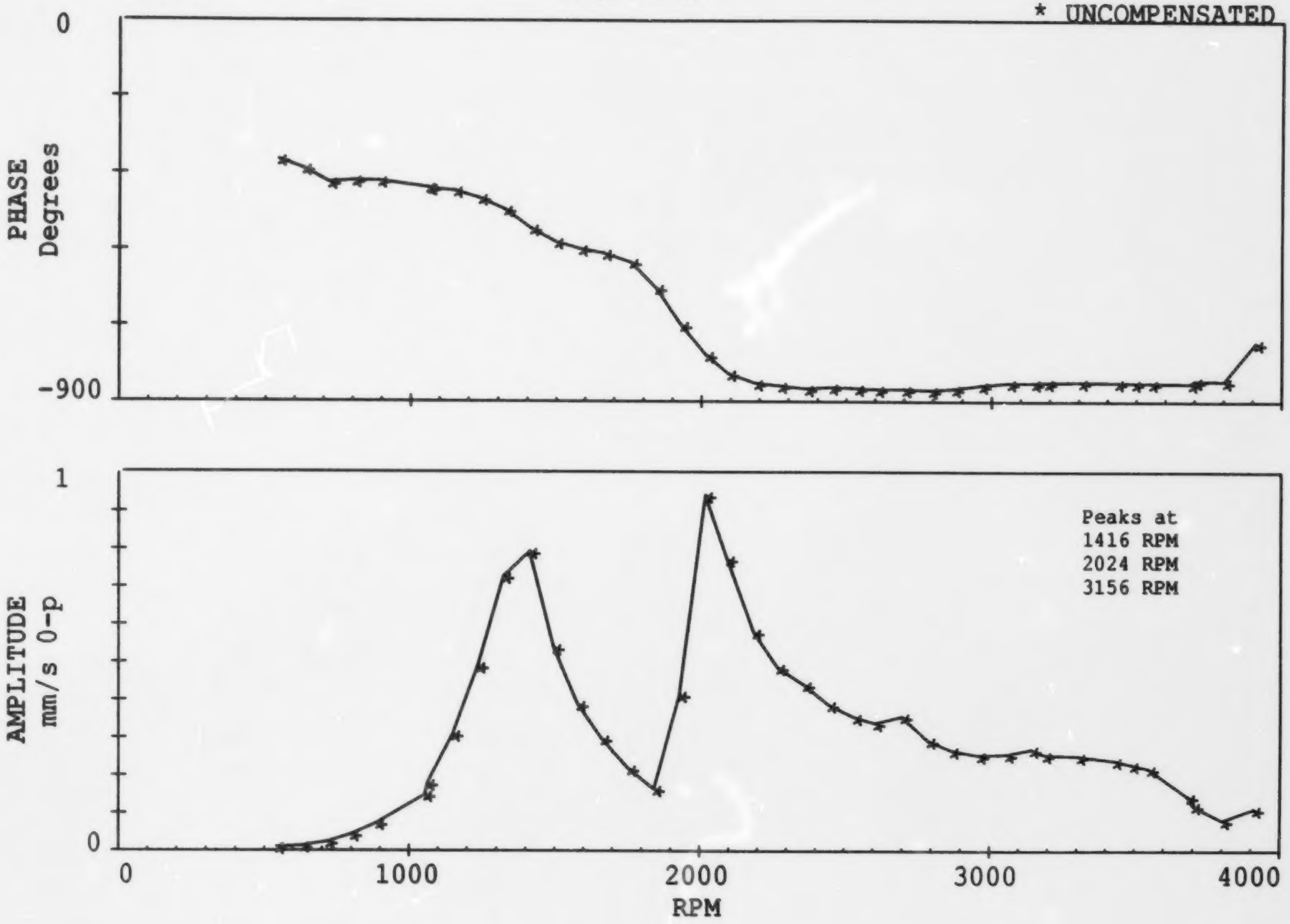


FIGURE 143

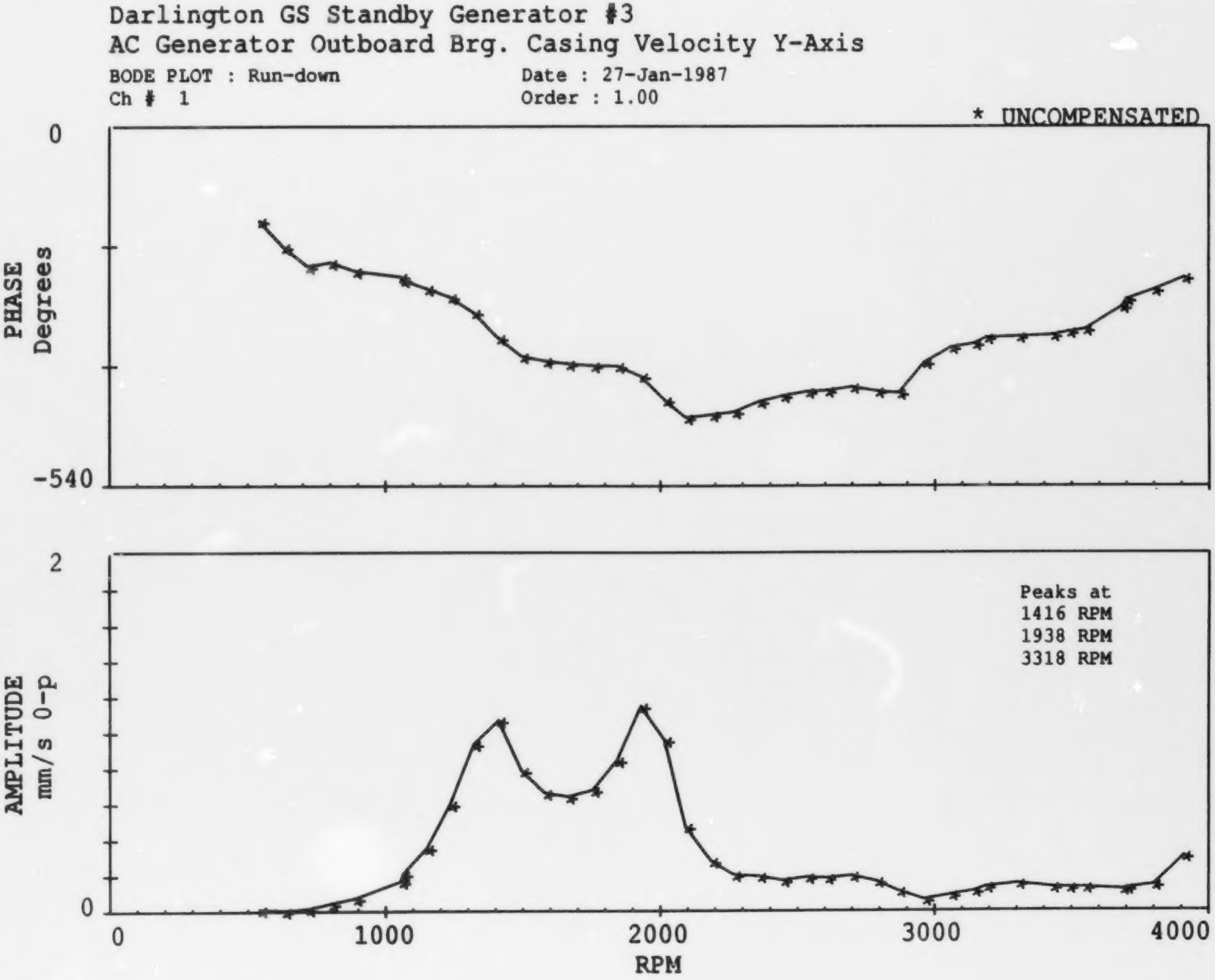

Darlington GS Standby Generator #3
AC Generator Outboard Brg. Casing Velocity Y-Axis
BODE PLOT : Run-down
Date : 27-Jan-1987
Ch # 1
Order : 1.00
* UNCOMPENSATED
0
-540
PHASE
Degrees
2
0
AMPLITUDE
mm/s 0-p
Peaks at
1416 RPM
1938 RPM
3318 RPM
0
1000
2000
3000
4000
RPM

FIGURE 144

Darlington GS Standby Generator #3
AC Generator Outboard Brg. Casing Velocity Axial
BODE PLOT : Run-down
Ch # 3
Date : 27-Jan-1987
Order : 1.00

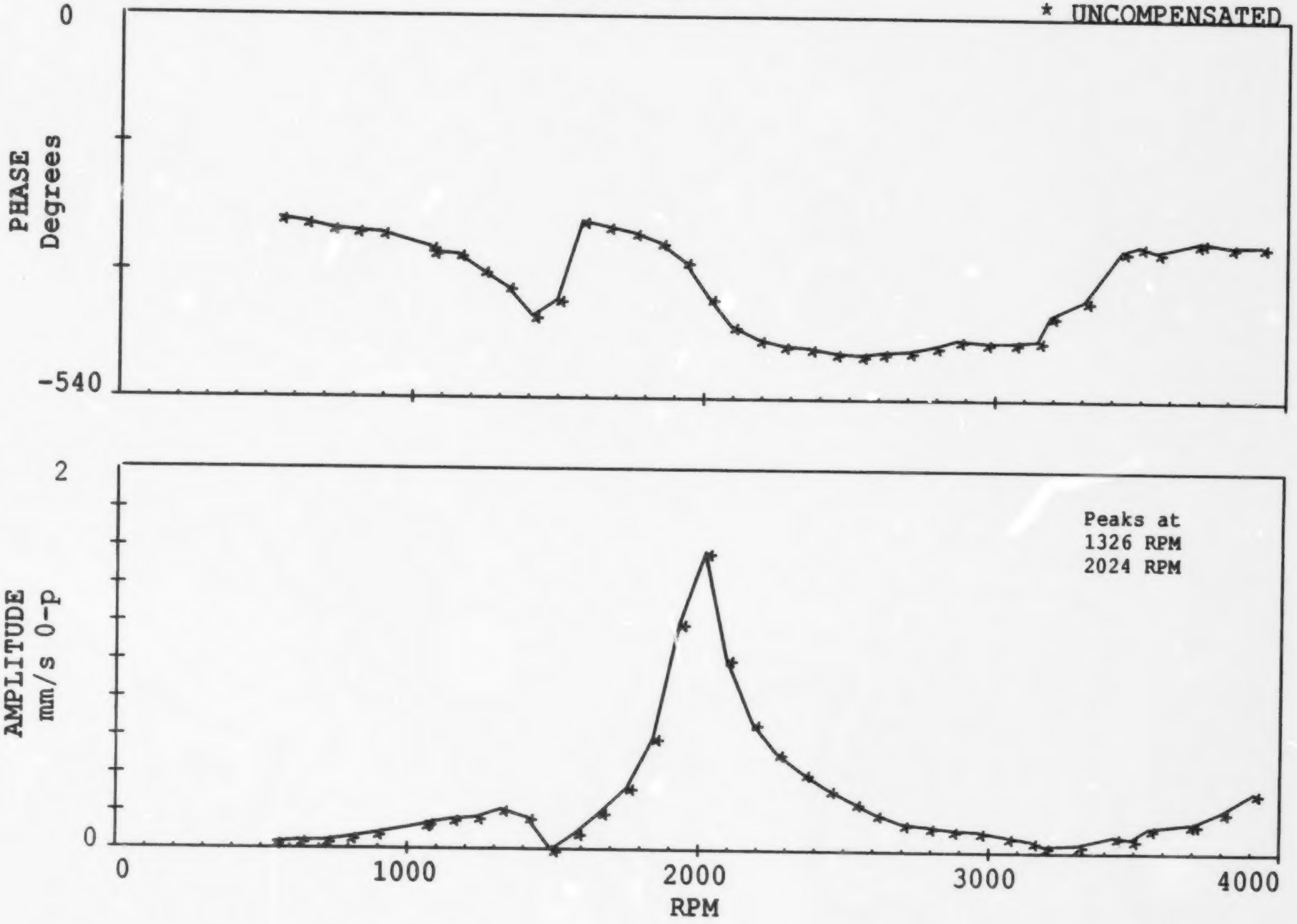


FIGURE 145

Darlington GS Standby Generator #3
AC Generator Inboard Brg. Casing Velocity X-Axis
BODE PLOT : Run-down
Ch # 5
Date : 27-Jan-1987
Order : 1.00

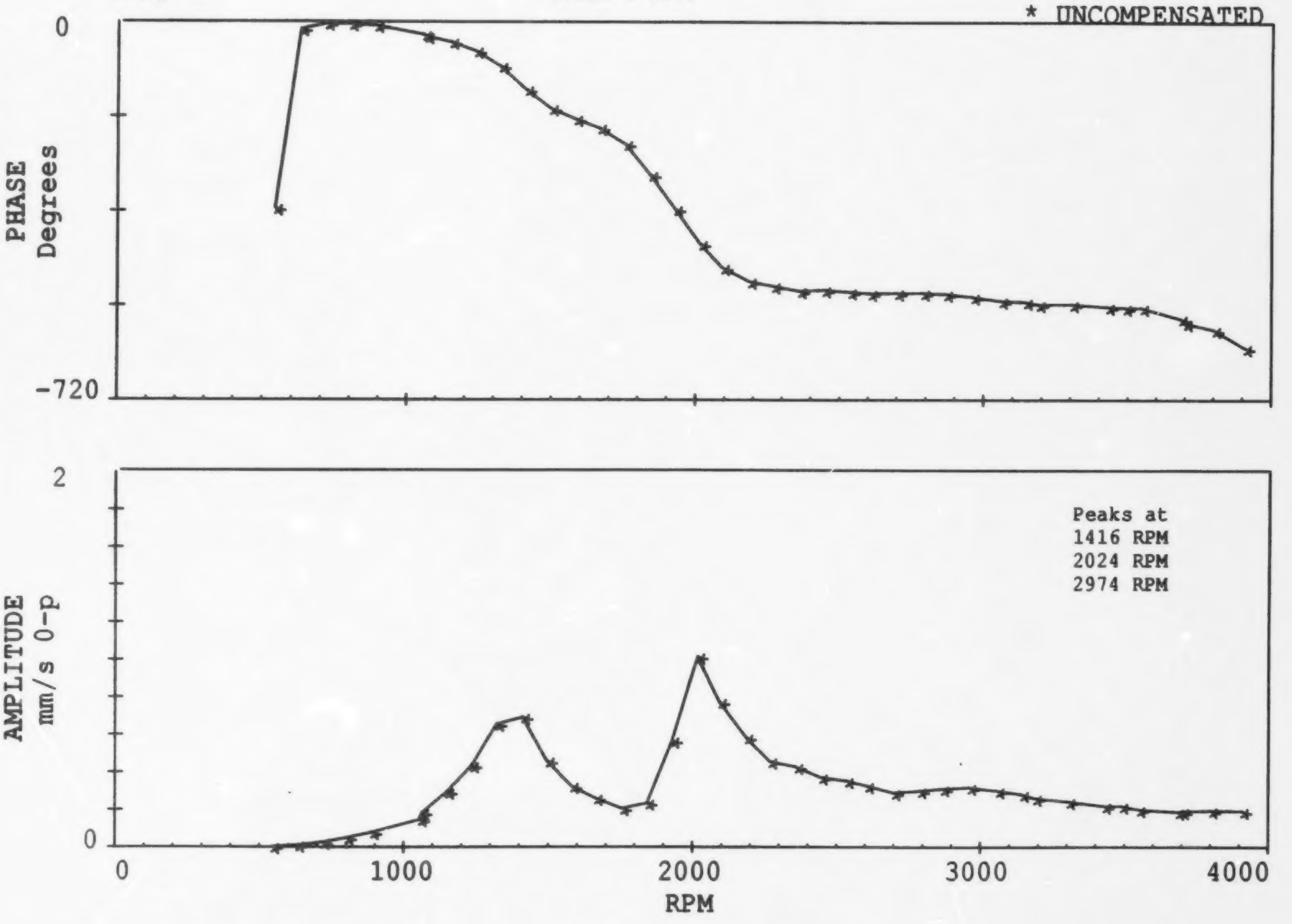


FIGURE 146

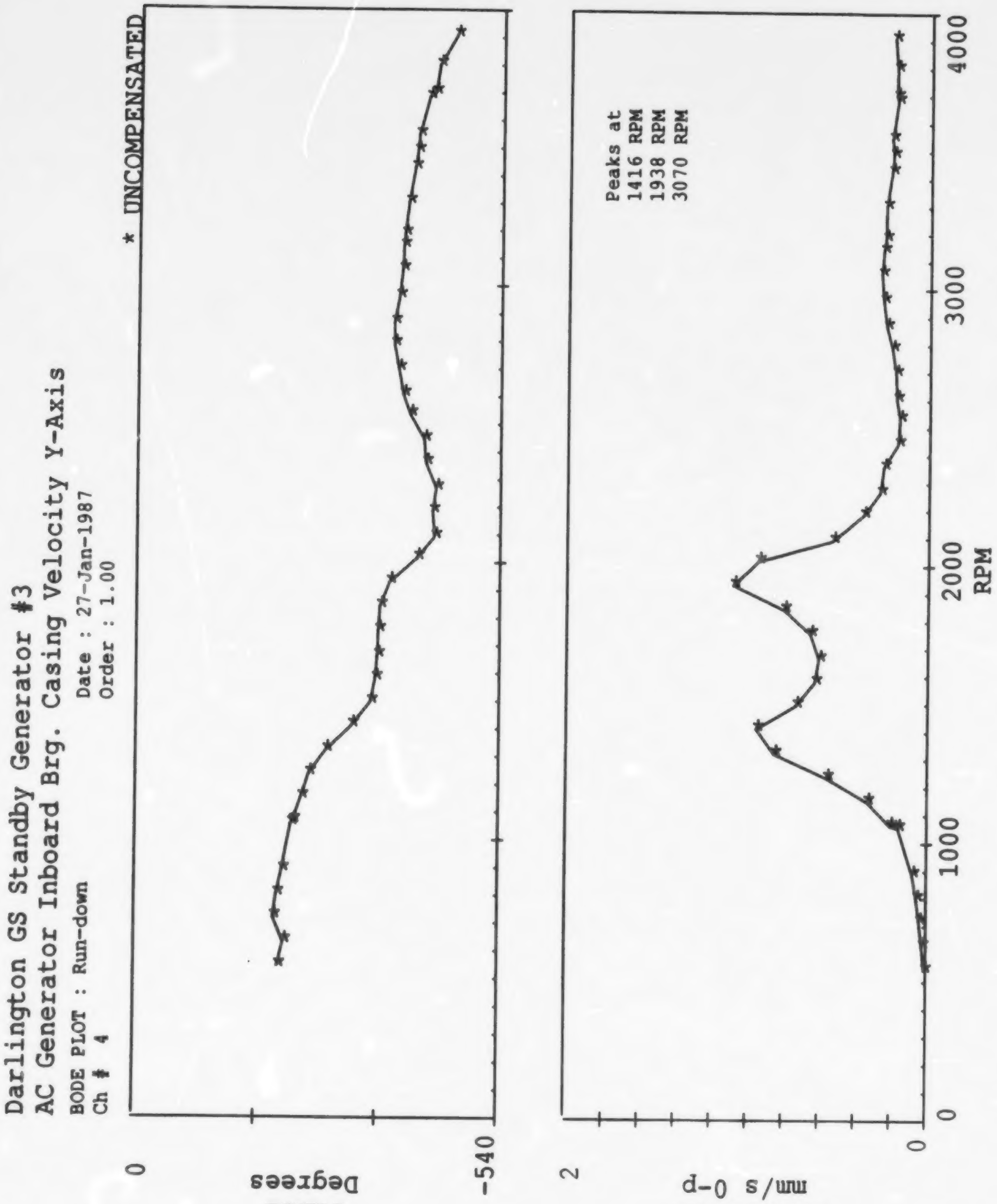

Darlington GS Standby Generator #3
AC Generator Inboard Brg. Casing Velocity Y-Axis
BODE PLOT : Run-down
Ch # 4
Date : 27-Jan-1987
Order : 1.00
* UNCOMPENSATED
PHASE
Degrees
0
-540
AMPLITUDE
mm/s 0-p
2
0
Peaks at
1416 RPM
1938 RPM
3070 RPM
0
1000
2000
3000
4000
RPM

FIGURE 147

Darlington GS Standby Generator #3
AC Generator Inboard Brg. Casing Velocity Axial
BODE PLOT : Run-down
Ch # 6
Date : 27-Jan-1987
Order : 1.00

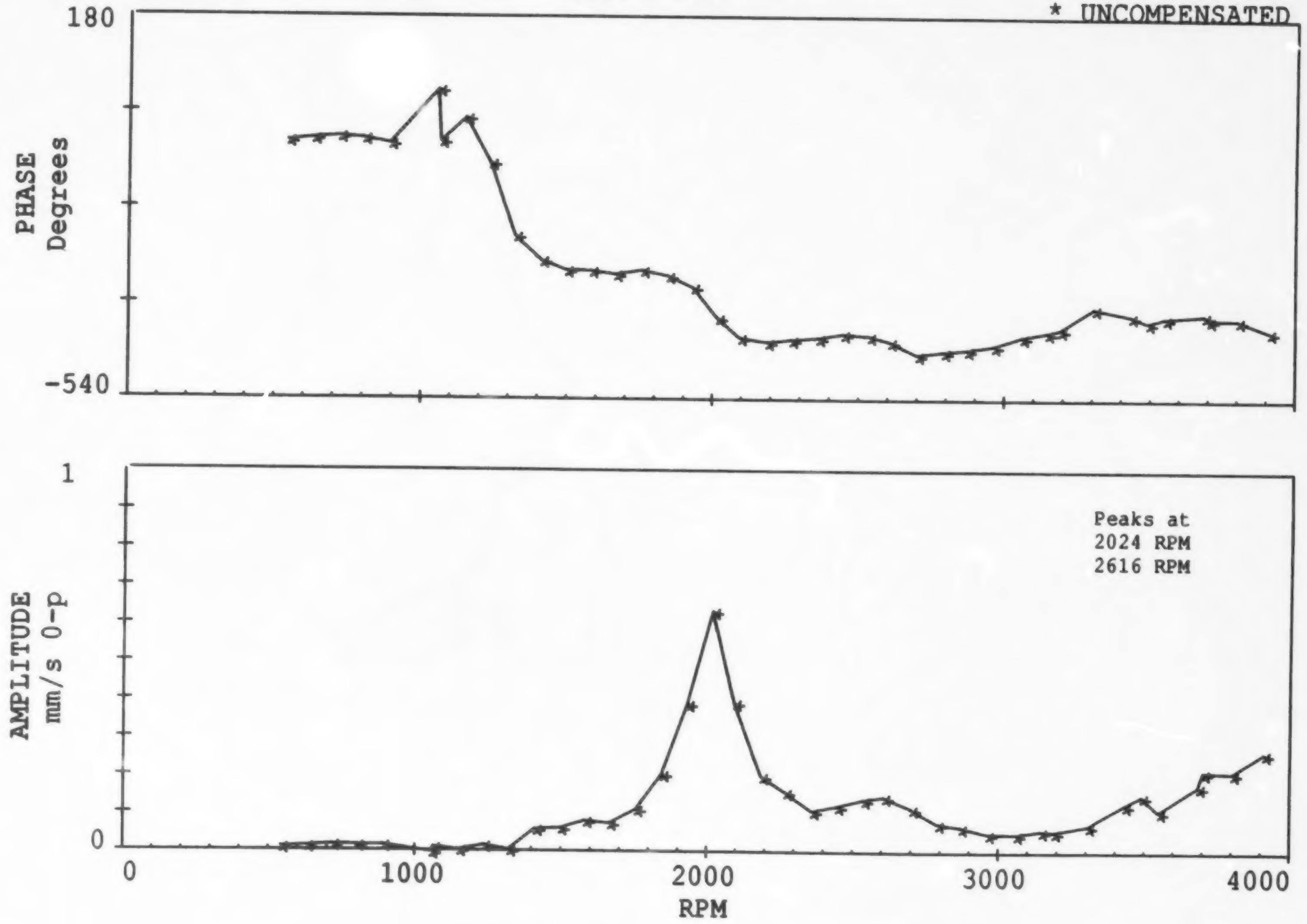


FIGURE 148

Darlington GS Standby Generator #3
AC Generator Outboard Brg. Shaft Displacement Y-Axis
BODE PLOT : Run-down
Ch # 9
Date : 27-Jan-1987
Order : 1.00

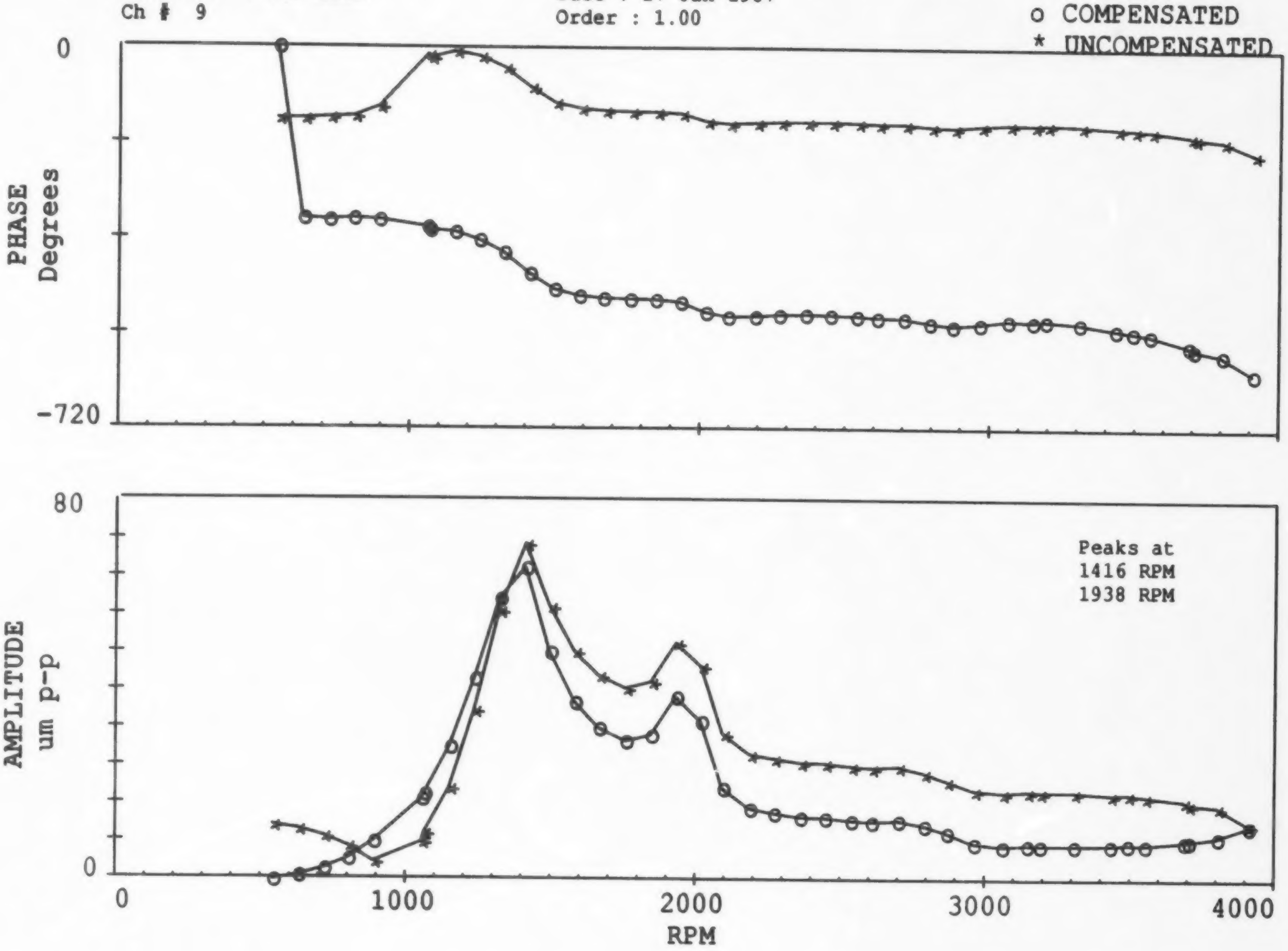


FIGURE 149

Darlington GS Standby Generator #3
AC Generator Outboard Brg. Shaft Displacement X-Axis

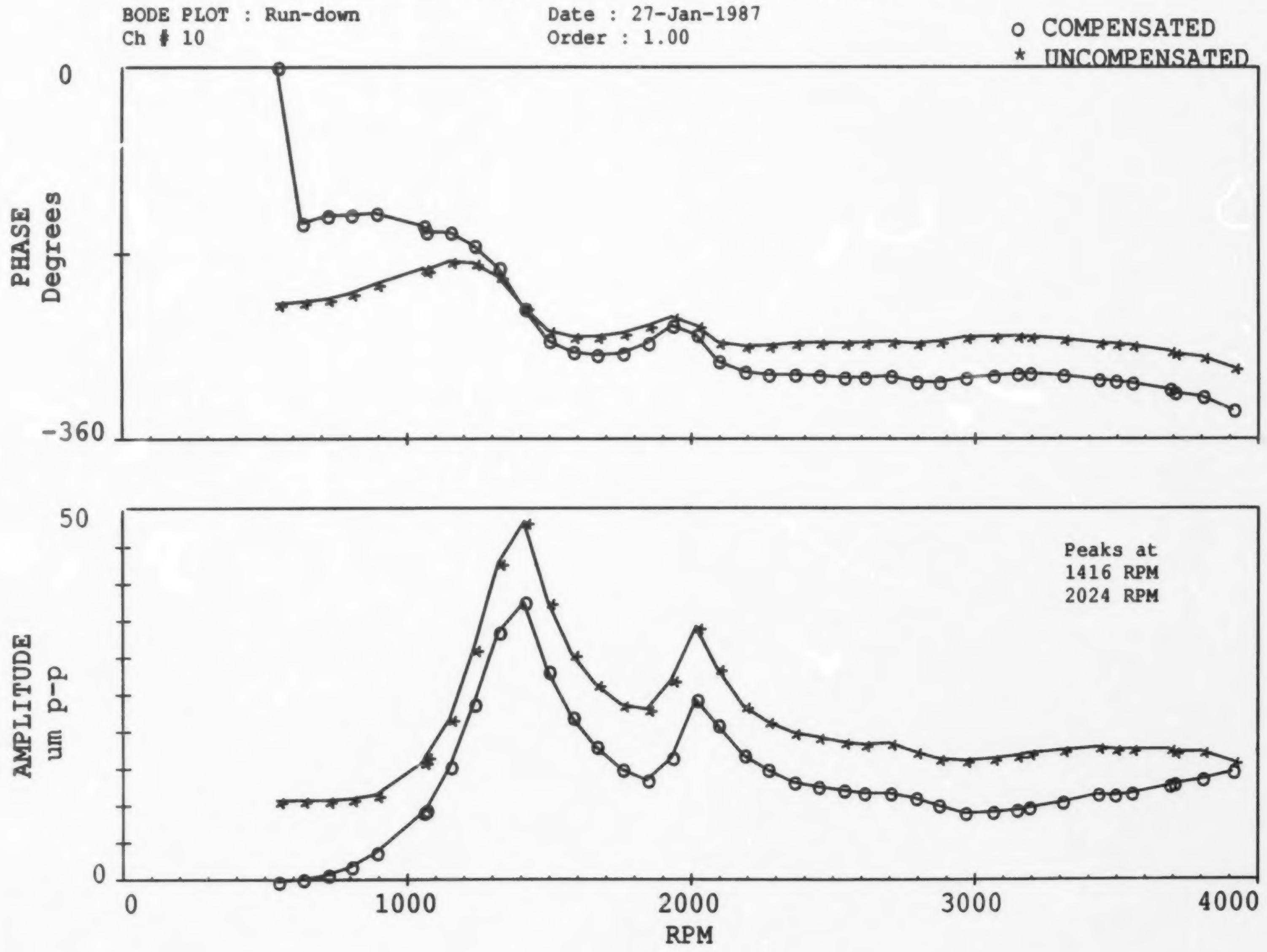


FIGURE 150

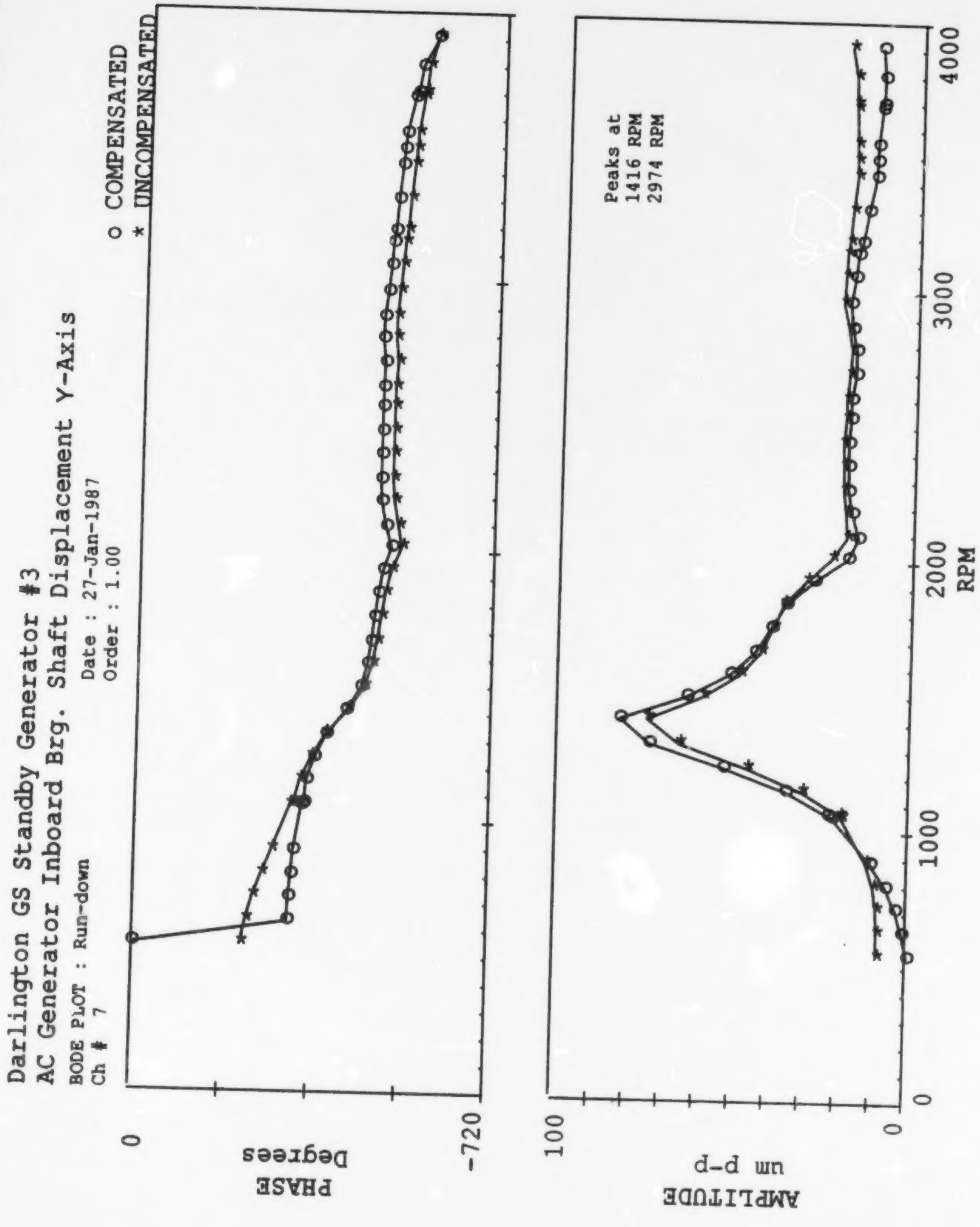

Darlington GS Standby Generator #3
AC Generator Inboard Brg. Shaft Displacement Y-Axis
BODE PLOT : Run-down
Ch # 7
Date : 27-Jan-1987
Order : 1.00
o COMPENSATED
* UNCOMPENSATED
PHASE
Degrees
0
-720
AMPLITUDE
um p-p
100
0
Peaks at
1416 RPM
2974 RPM
0
1000
2000
3000
4000
RPM

FIGURE 151

Darlington GS Standby Generator #3
AC Generator Inboard Brg. Shaft Displacement X-Axis

BODE PLOT : Run-down
Ch # 8

Date : 27-Jan-1987
Order : 1.00

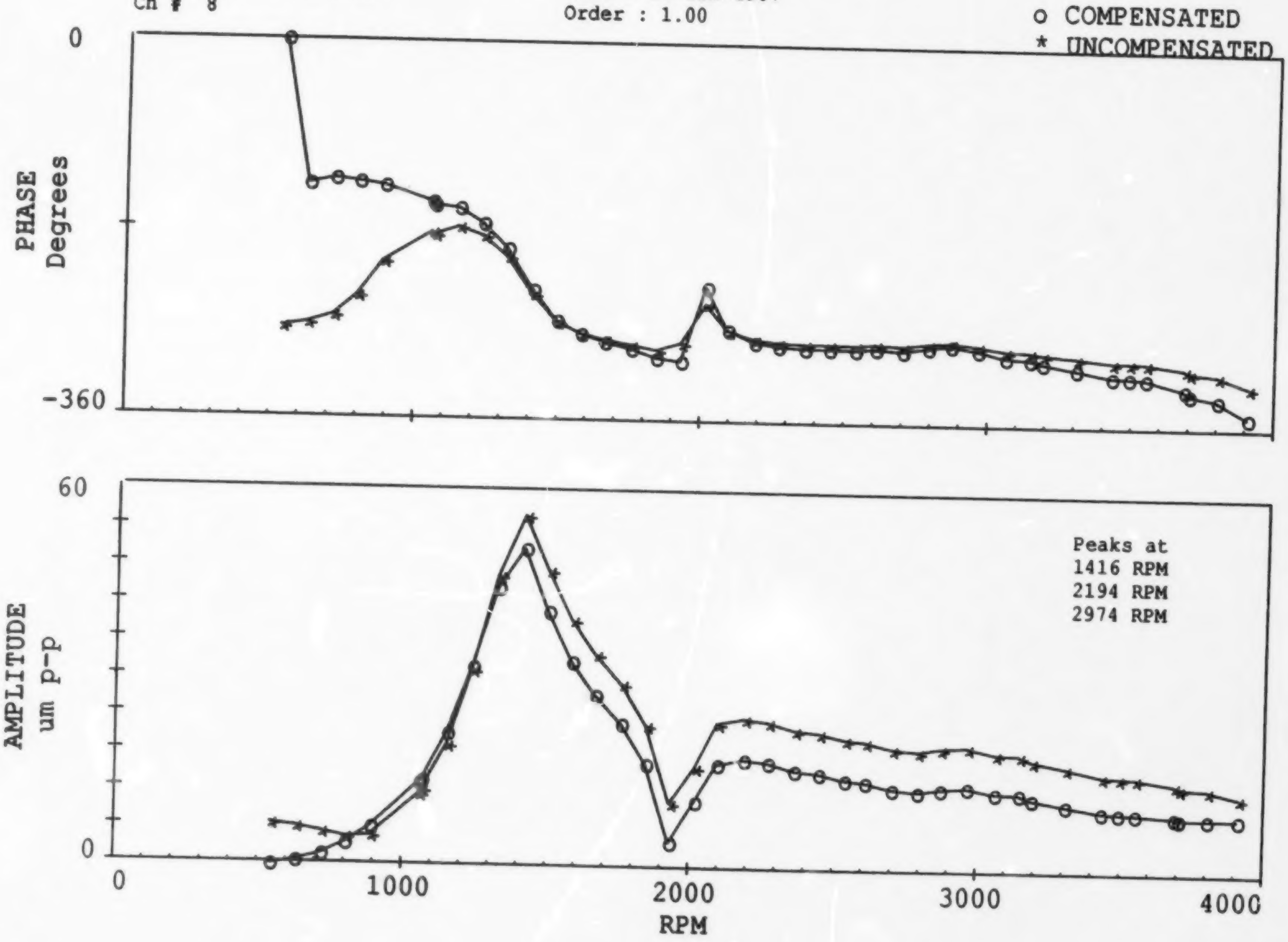


FIGURE 152

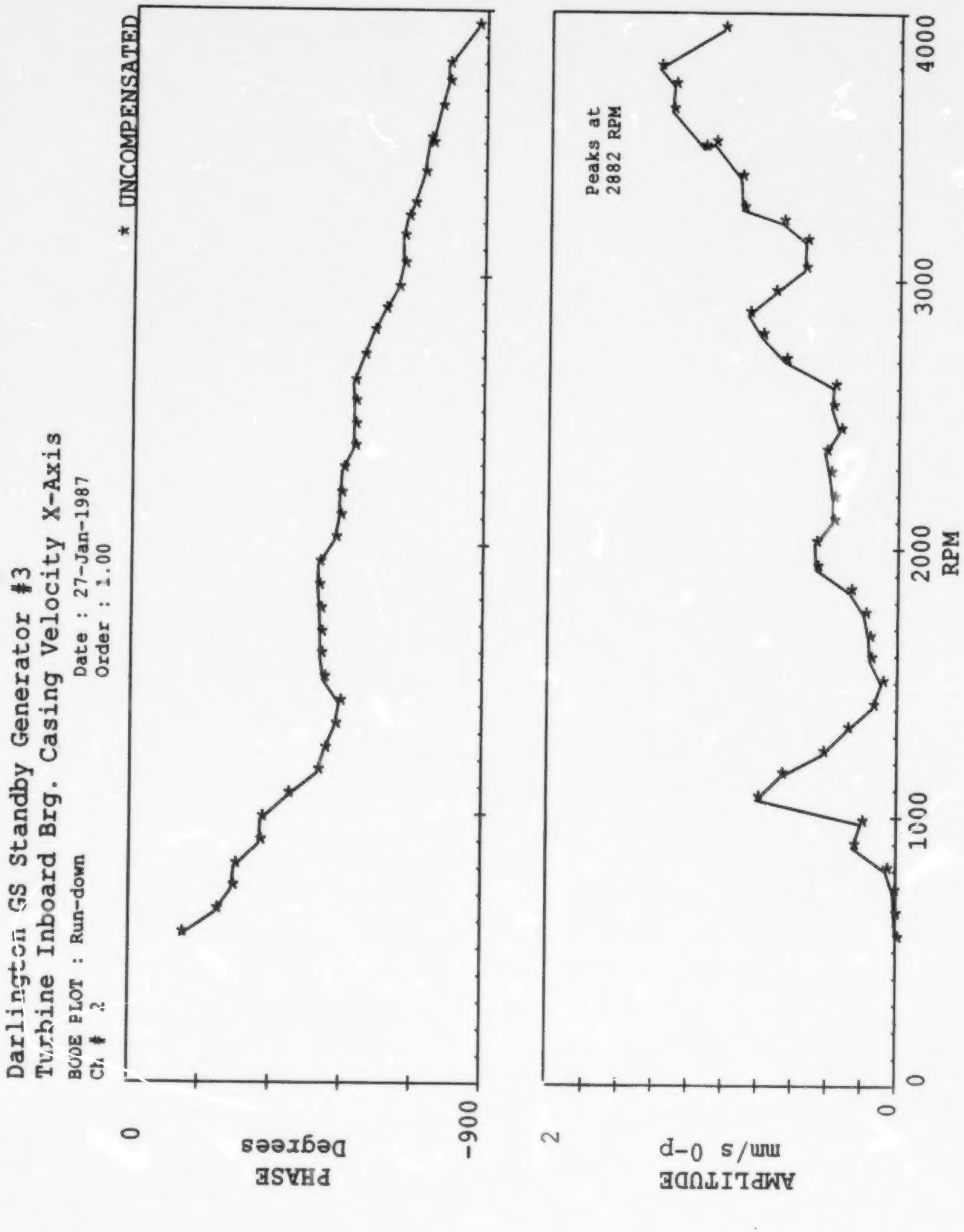

Darlington GS Standby Generator #3
Turbine Inboard Brg. Casing Velocity X-Axis
BODE PLOT : Run-down
Ch # 2
Date : 27-Jan-1987
Order : 1.00
* UNCOMPENSATED
PHASE
Degrees
0
-900
AMPLITUDE
mm/s 0-p
2
0
Peaks at
2882 RPM
0
1000
2000
3000
4000
RPM

FIGURE 153

Darlington GS Standby Generator #3
Turbine Inboard Brg. Casing Velocity Y-Axis
BODE PLOT : Run-down
Ch # 1
Date : 27-Jan-1987
Order : 1.00

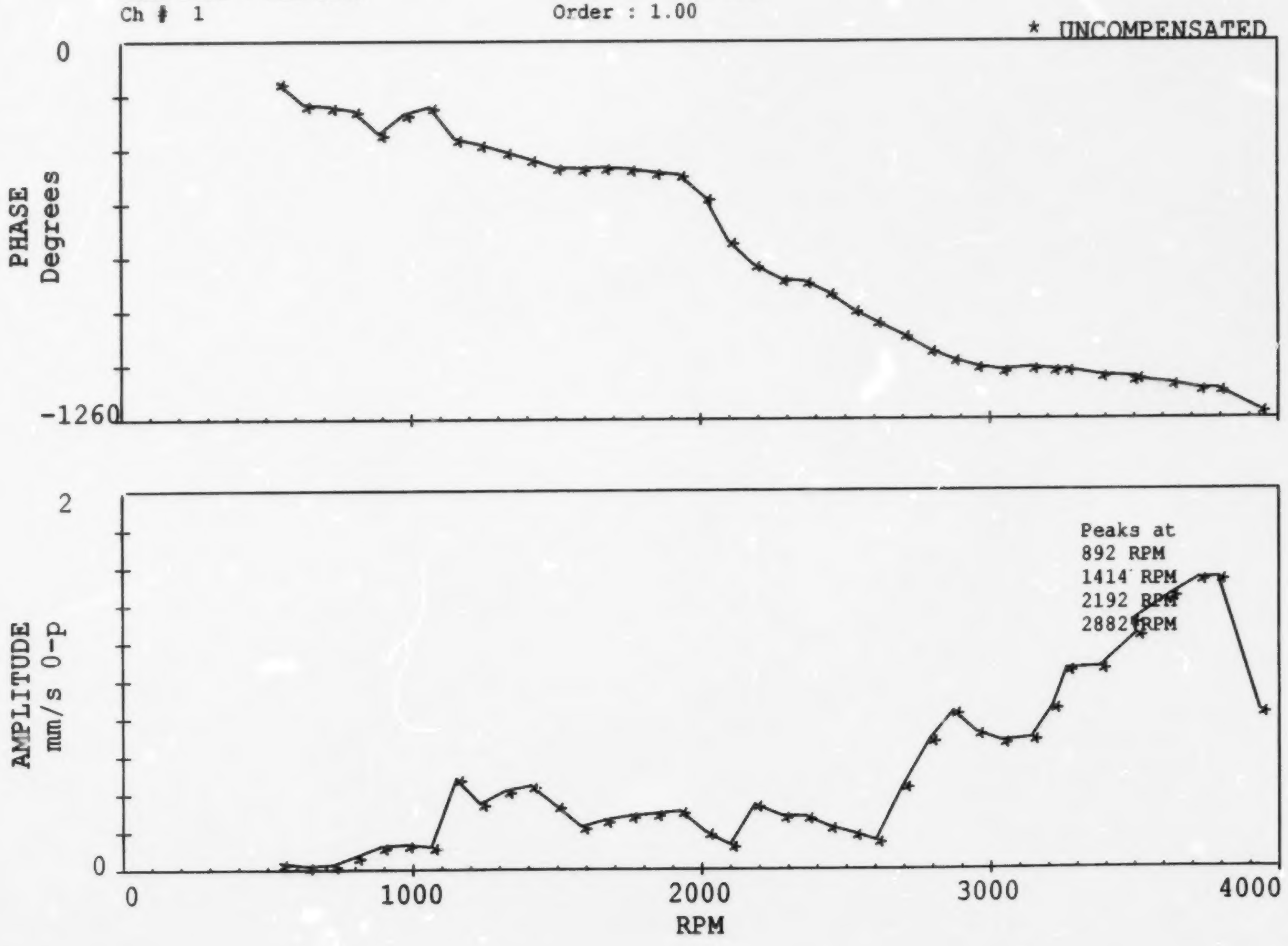


FIGURE 154

Darlington GS Standby Generator #3
Turbine Inboard Brg. Casing Velocity Axial

BODE PLOT : Run-down
Ch # 3

Date : 27-Jan-1987
Order : 1.00

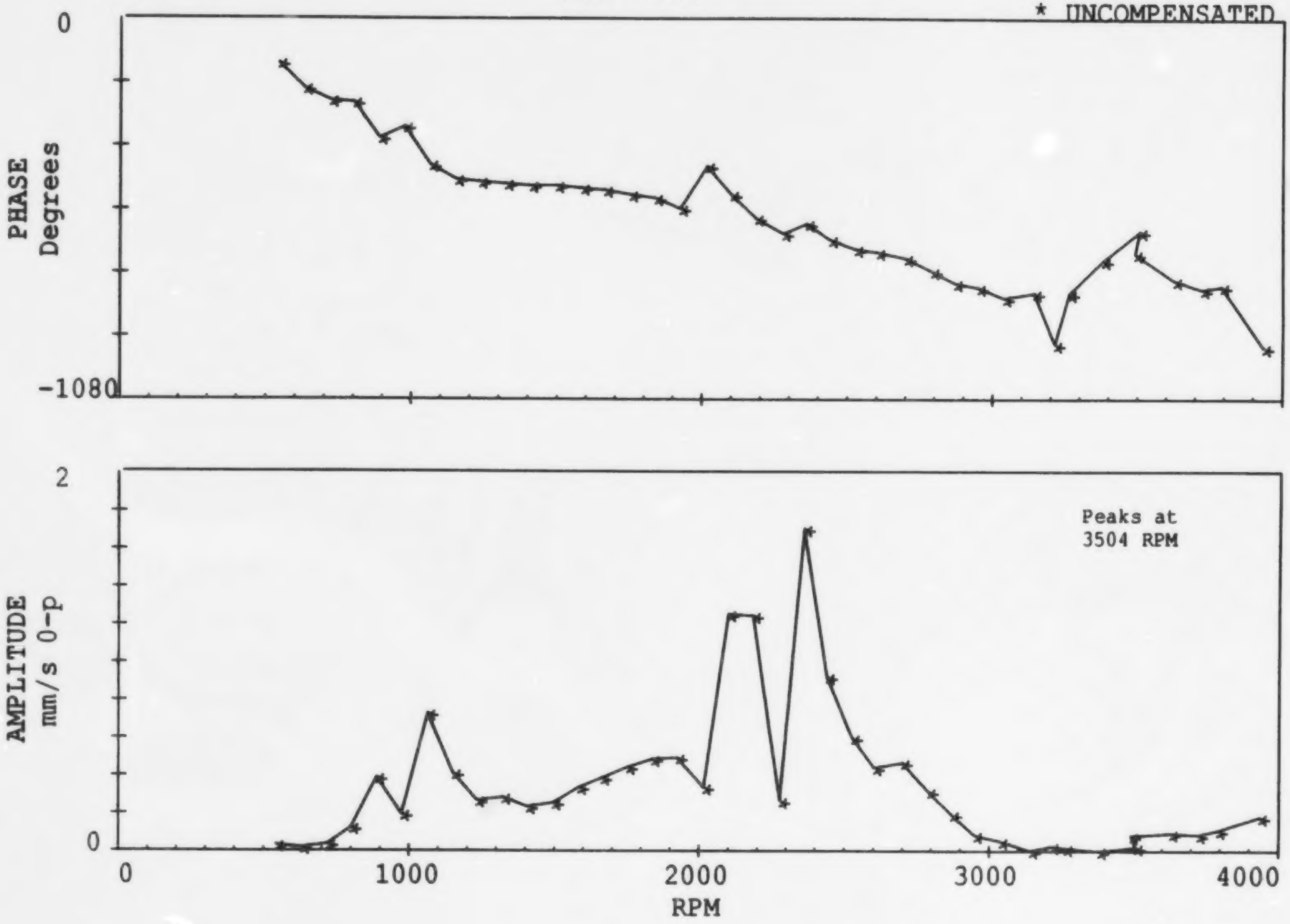


FIGURE 155

Darlington GS Standby Generator #3
Turbine Inboard Brg. Shaft Displacement X-Axis

BODE PLOT : Run-down
Ch # 6

Date : 27-Jan-1987
Order : 1.00

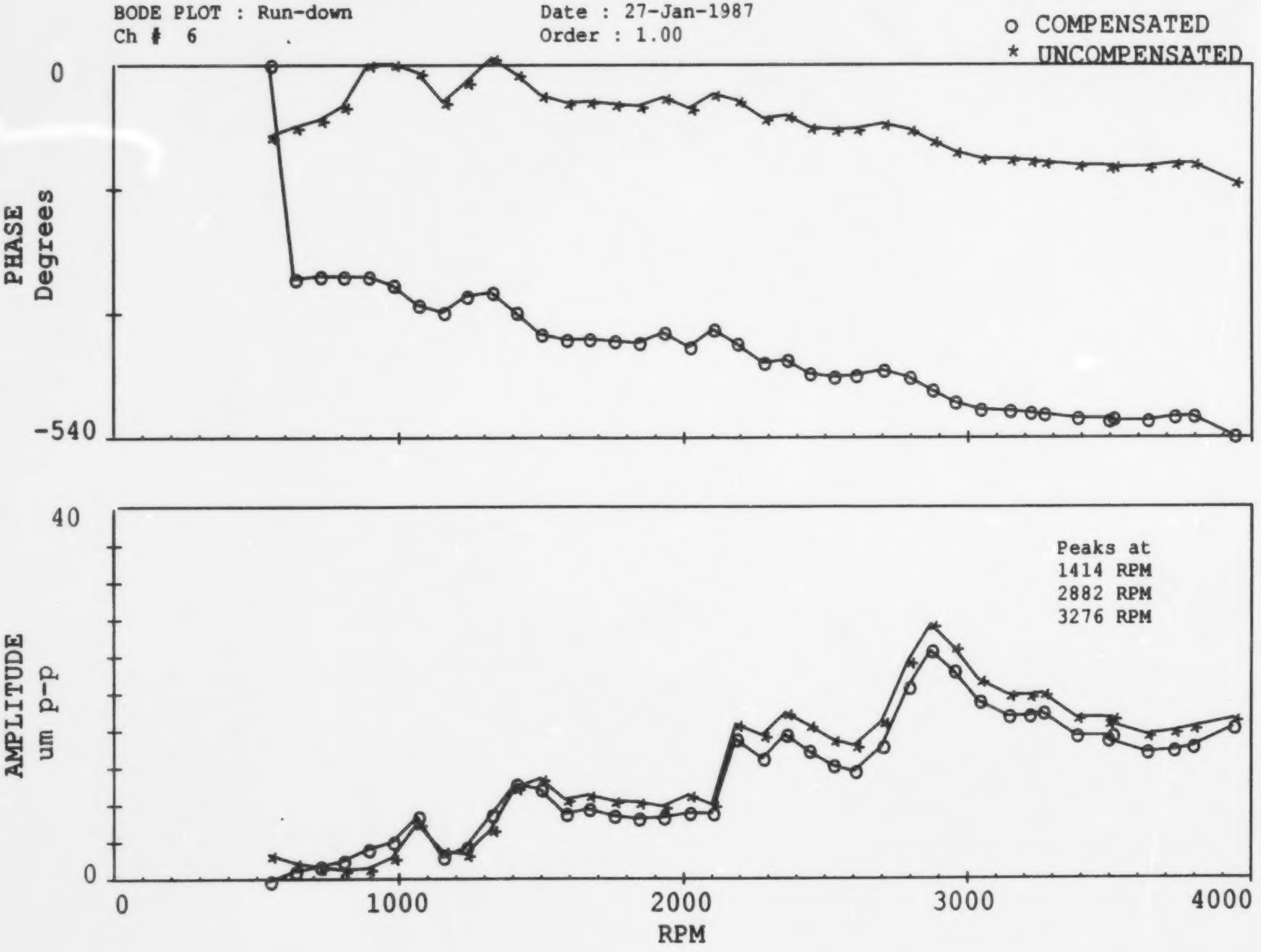


FIGURE 156

Darlington GS Standby Generator #3
Turbine Inboard Brg. Shaft Displacement Y-Axis

BODE PLOT : Run-down
Ch # 7

Date : 27-Jan-1987
Order : 1.00

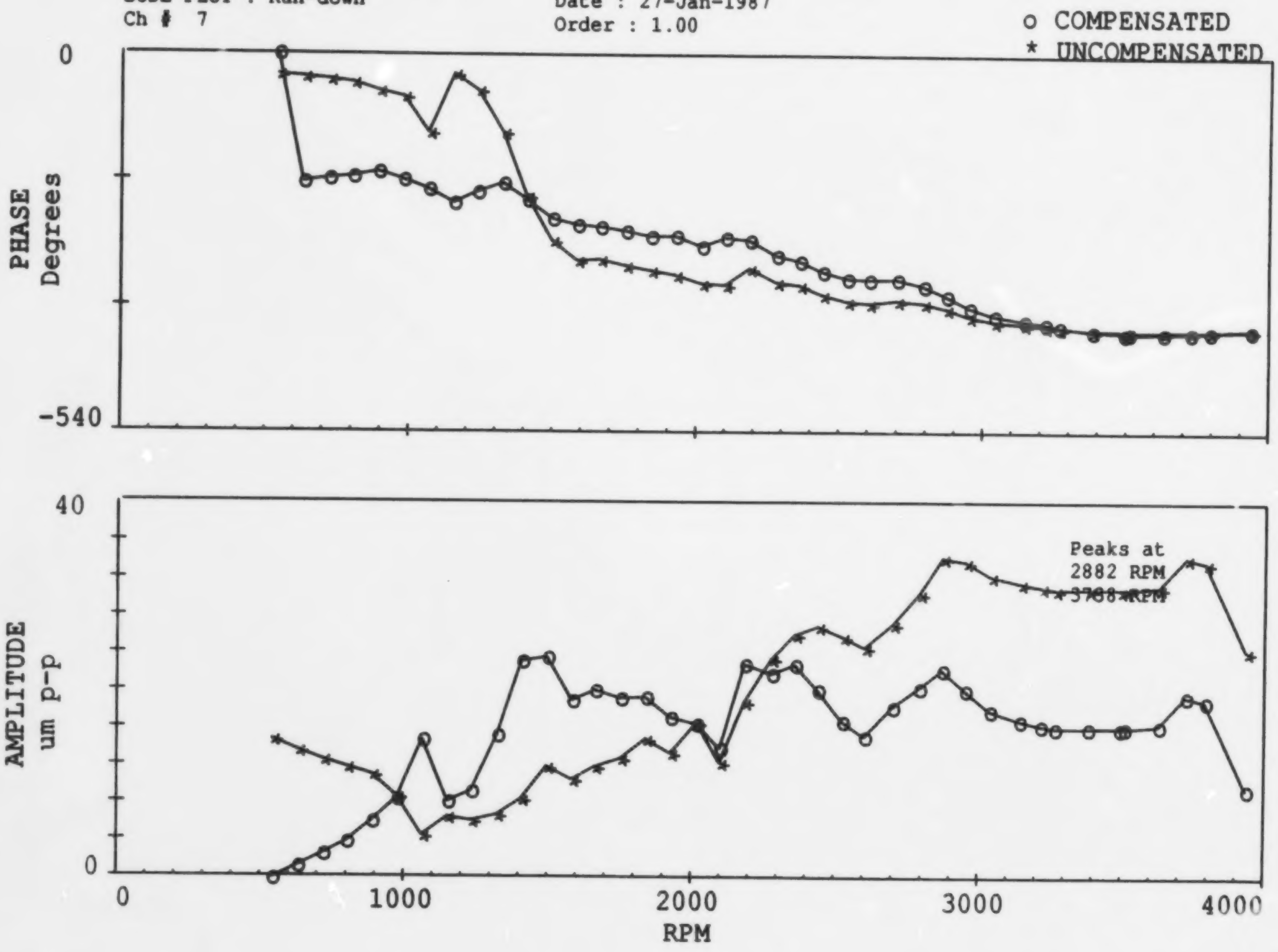
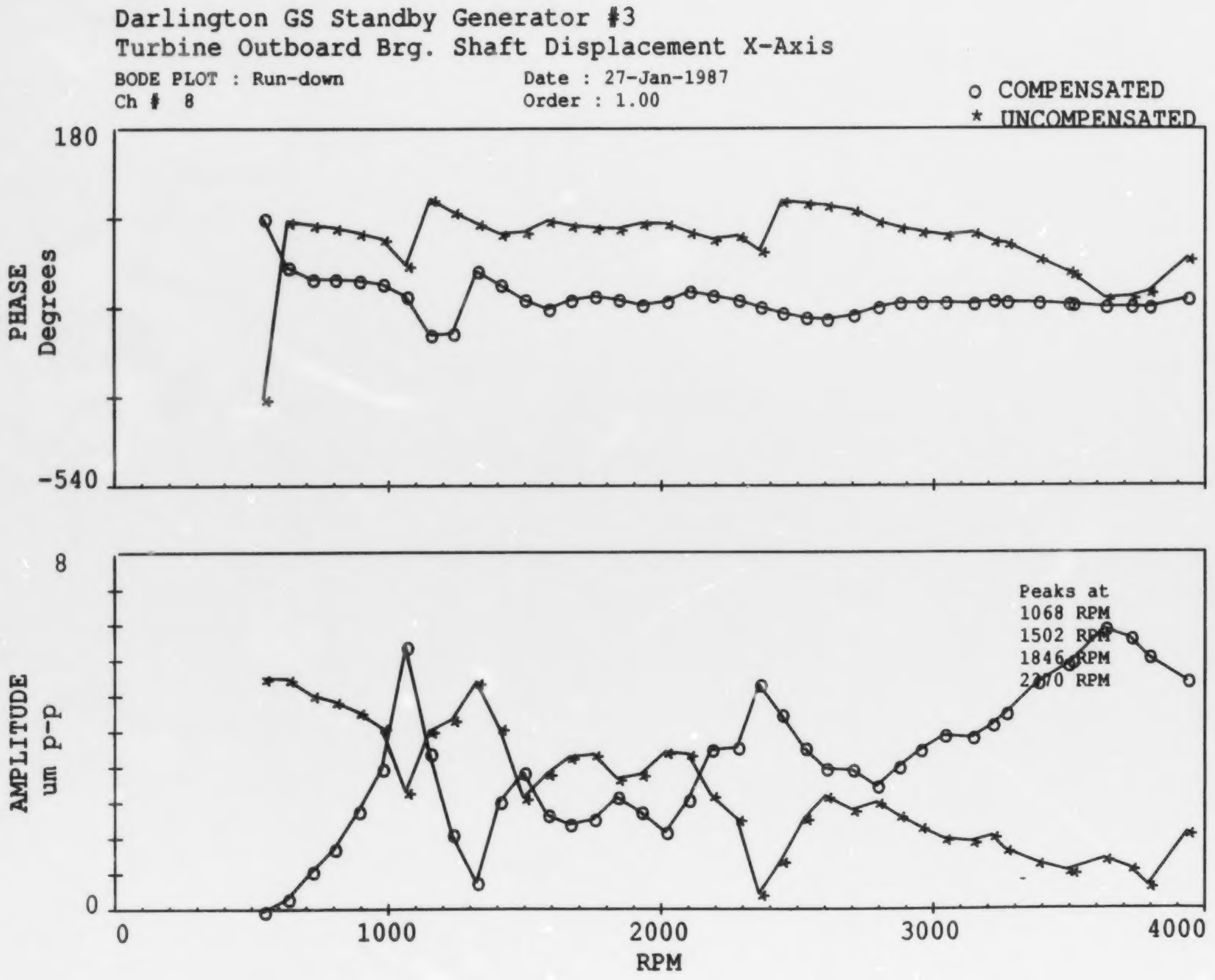


FIGURE 157



Darlington GS Standby Generator #3
Turbine Outboard Brg. Shaft Displacement X-Axis

FIGURE 158

Darlington GS Standby Generator #3
Turbine Outboard Brg. Shaft Displacement Y-Axis

BODE PLOT : Run-down
Ch # 9

Date : 27-Jan-1987
Order : 1.00

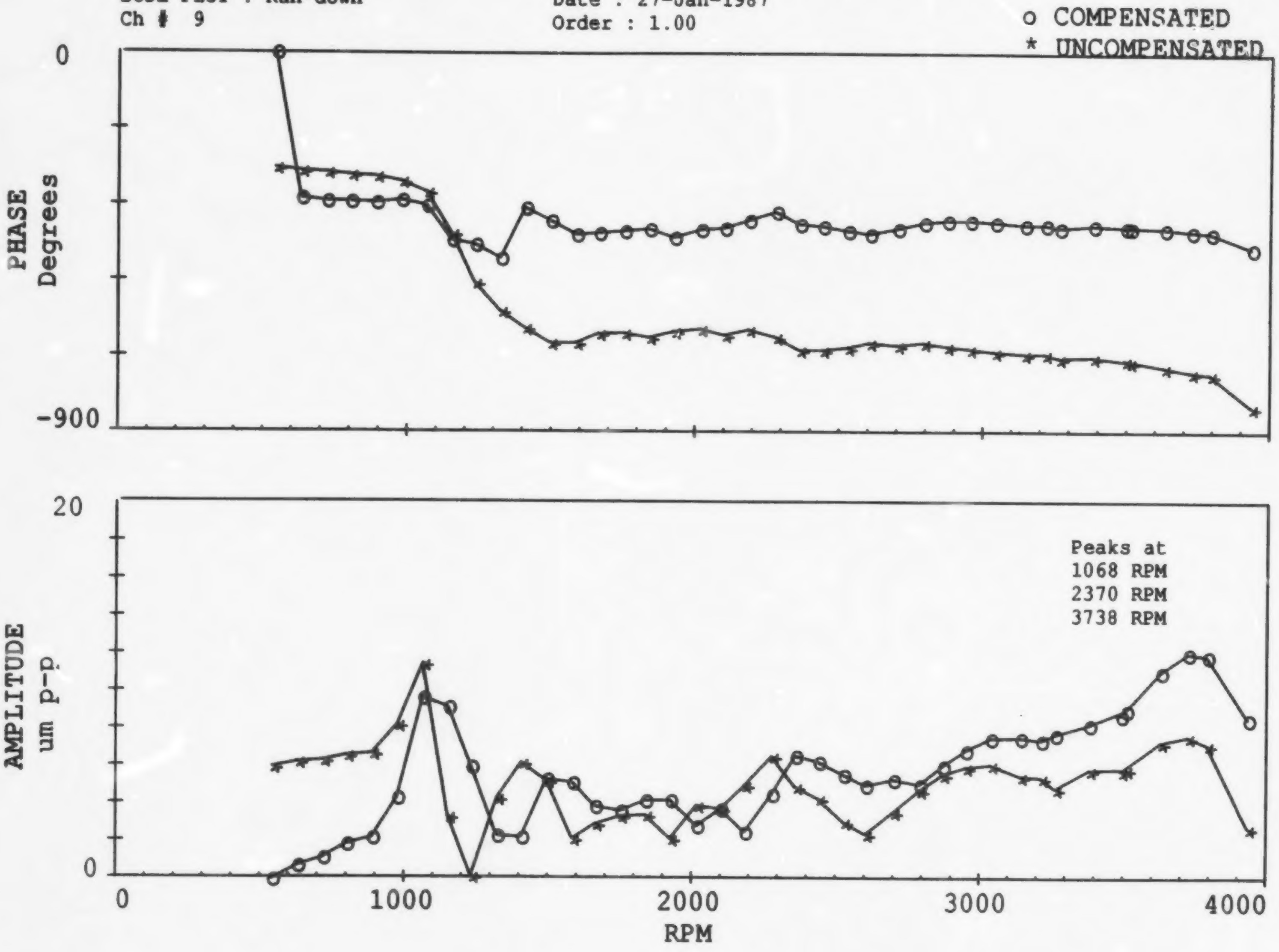


FIGURE 159

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 2 Outboard Brg. Casing Velocity X-Axis

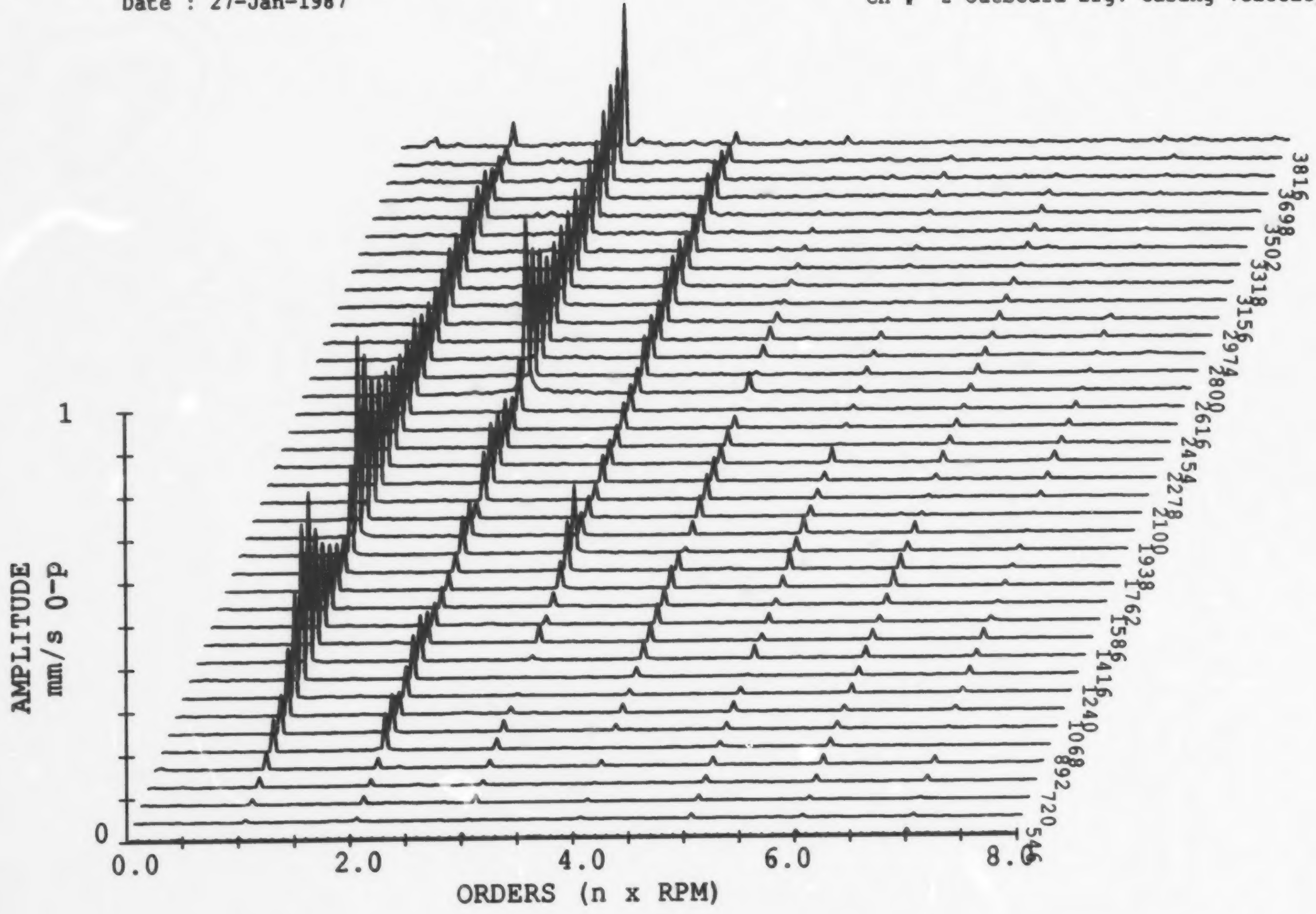


FIGURE 160

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 1 Outboard Brg. Casing Velocity Y-Axis

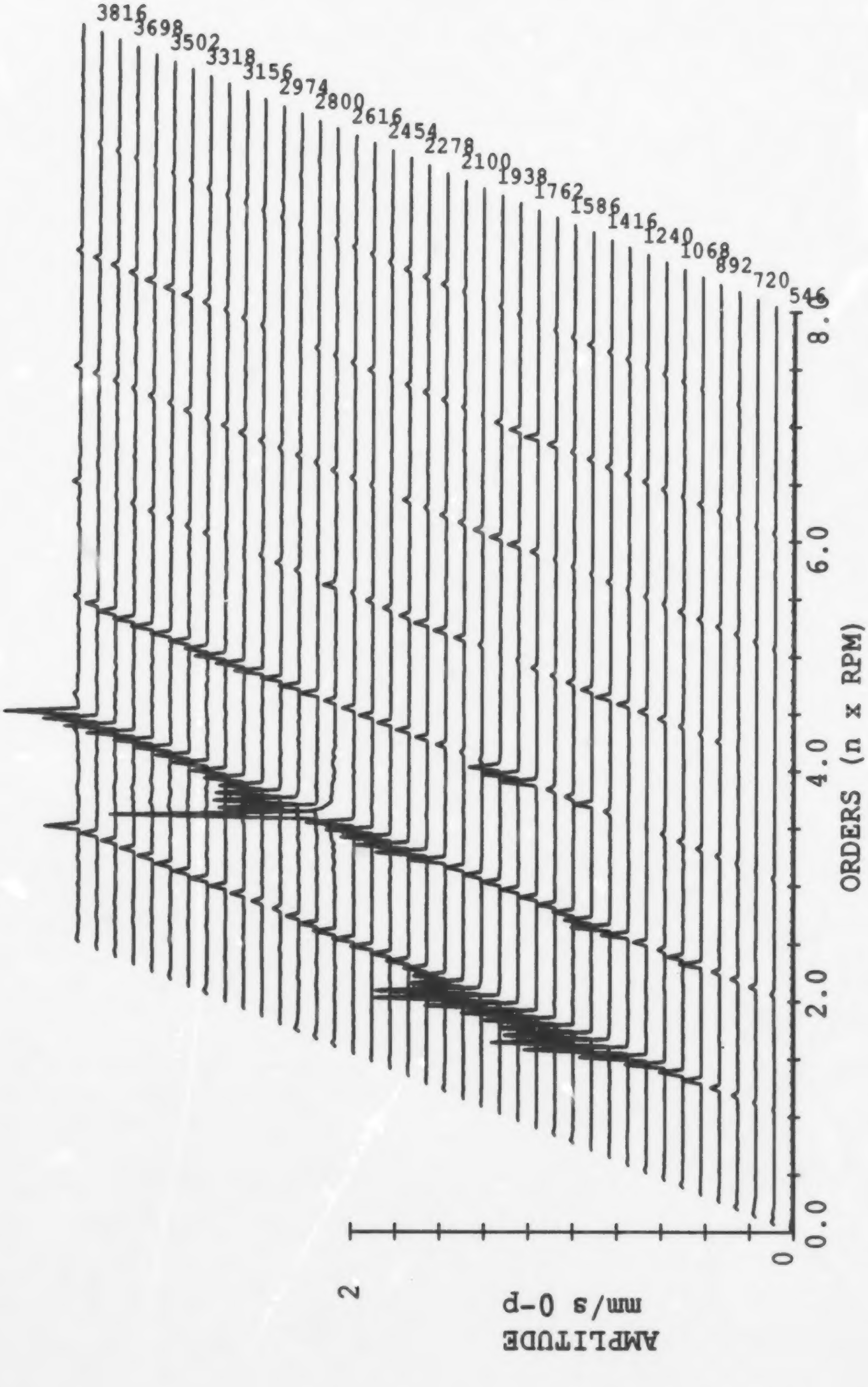


FIGURE 161

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 3 Outboard Brg. Casing Velocity Axial

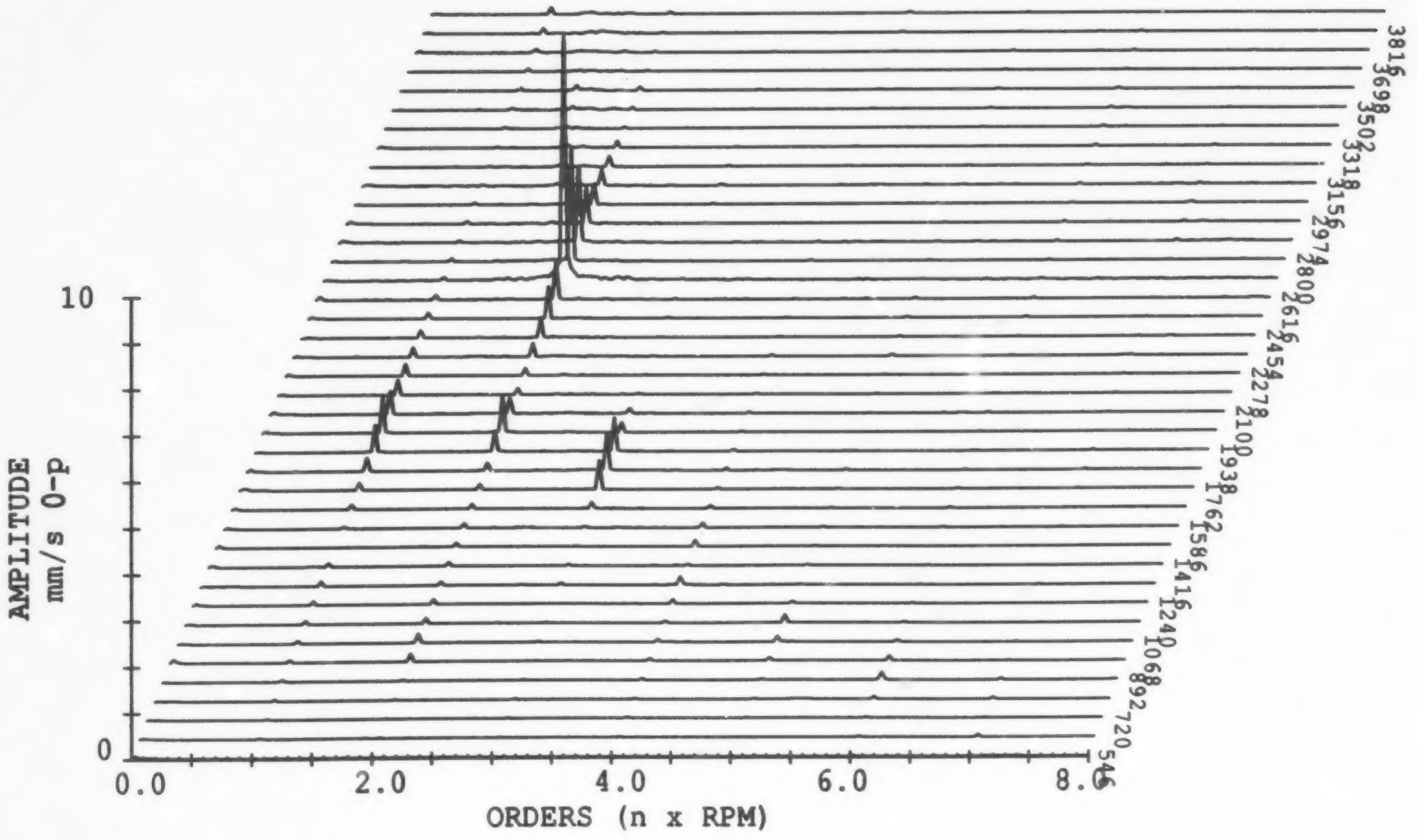


FIGURE 162

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 5 Inboard Brg. Casing Velocity X-Axis

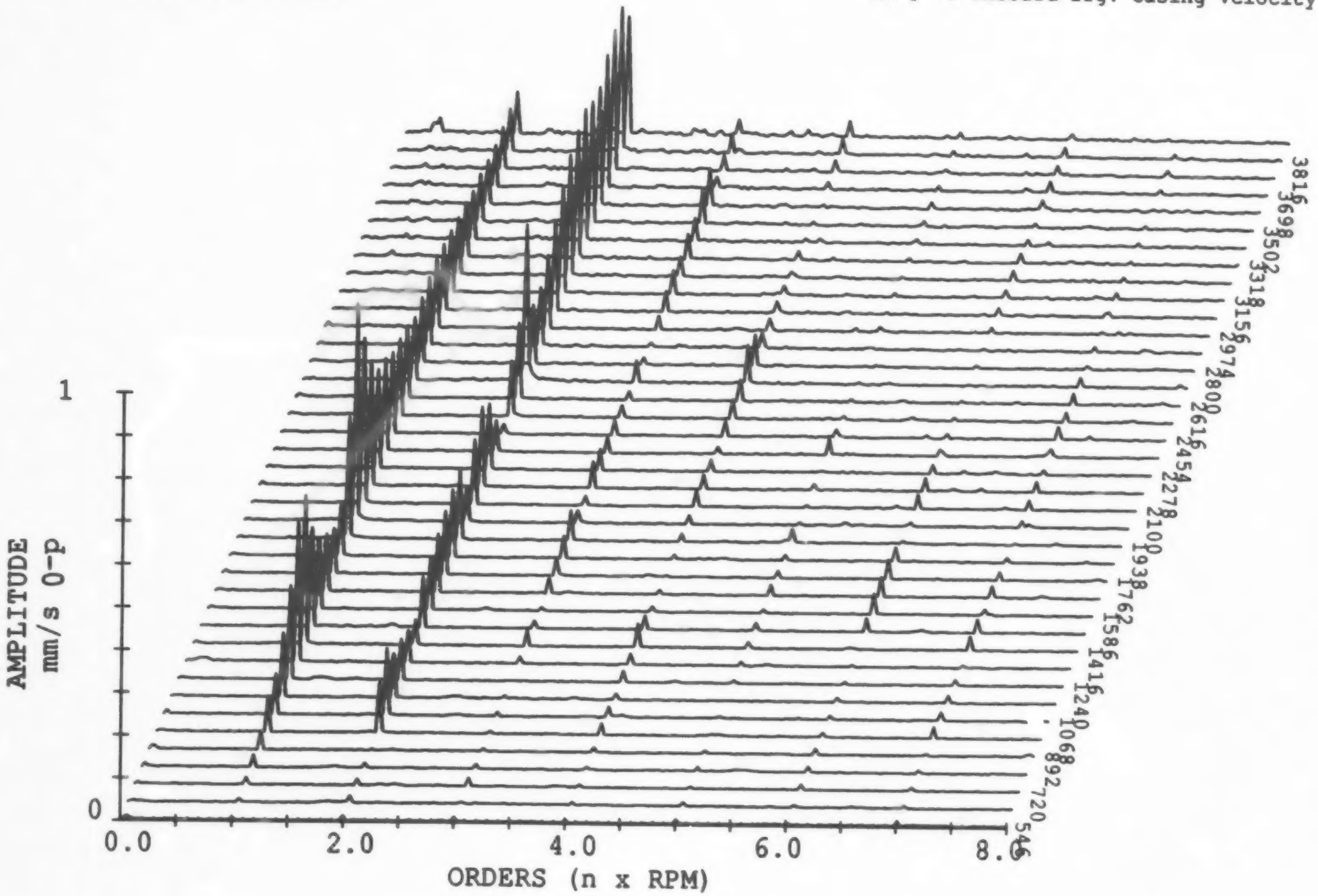


FIGURE 163

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 4 Inboard Brg. Casing Velocity Y-Axis

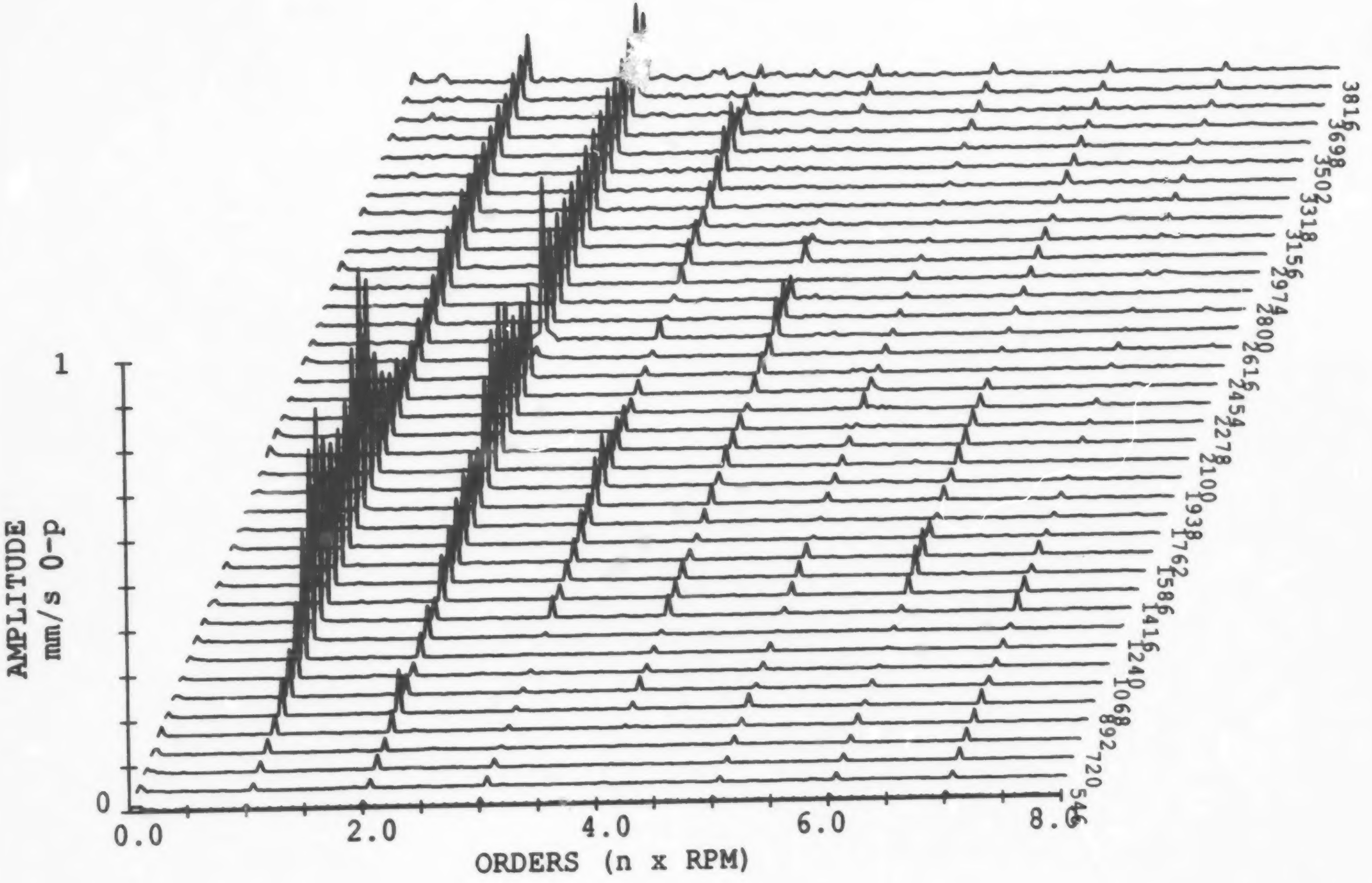
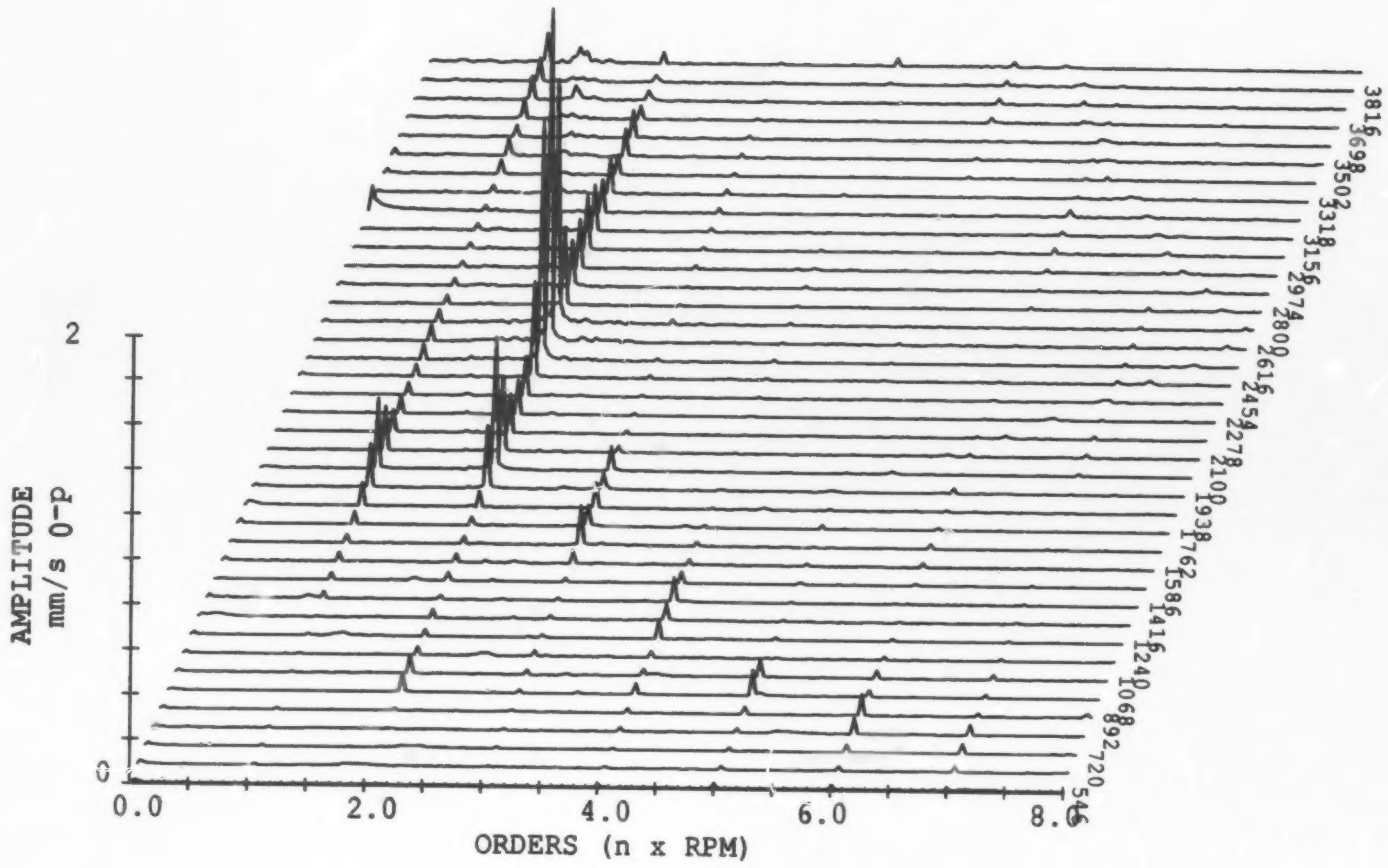


FIGURE 164


Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 6 Inboard Brg. Casing Velocity Axial

FIGURE 165

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 9 Outboard Brg. Shaft Displacement Y-Axis

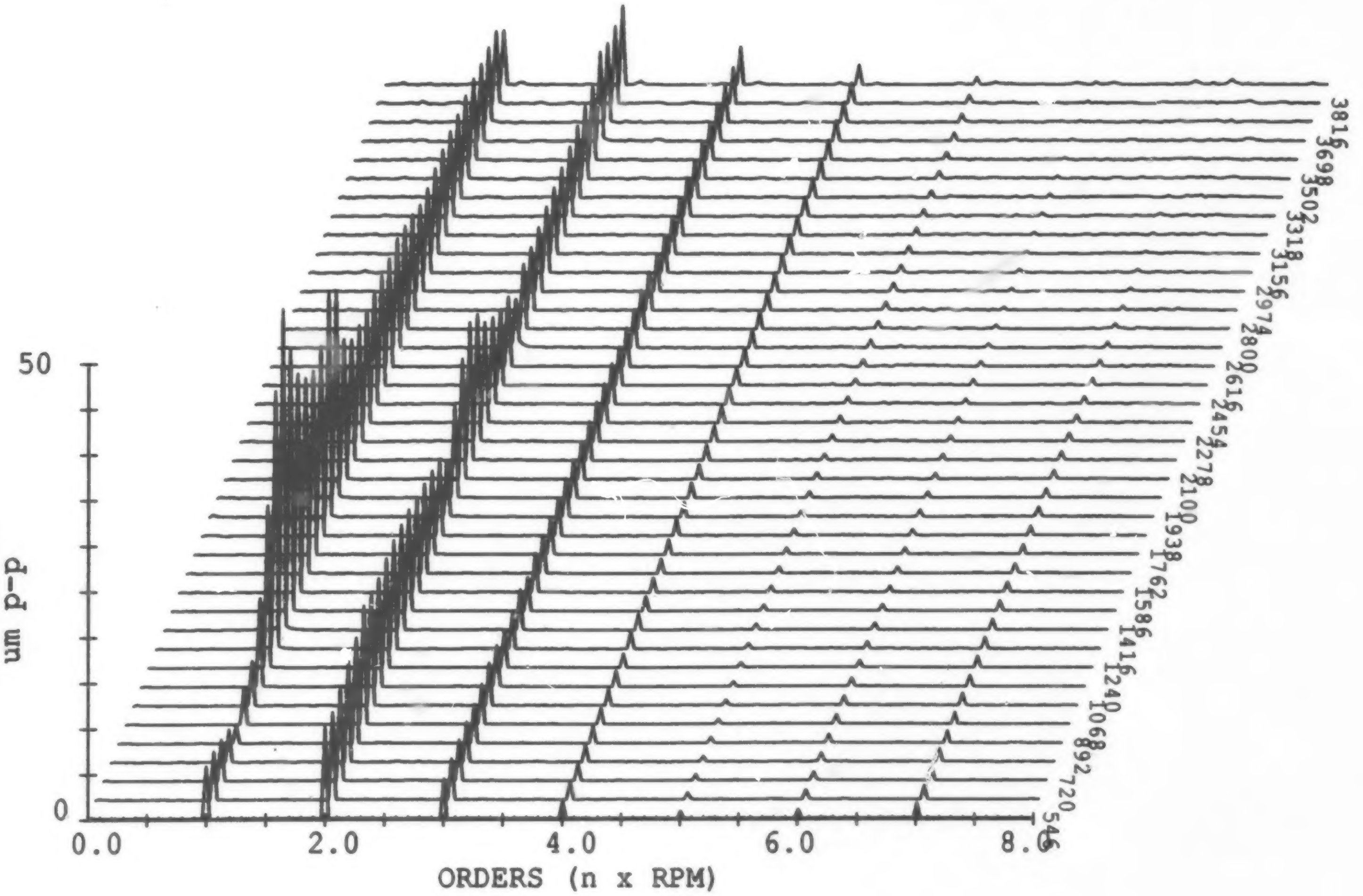


FIGURE 166

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 10 Outboard Brg. Shaft Displacement X-Axis

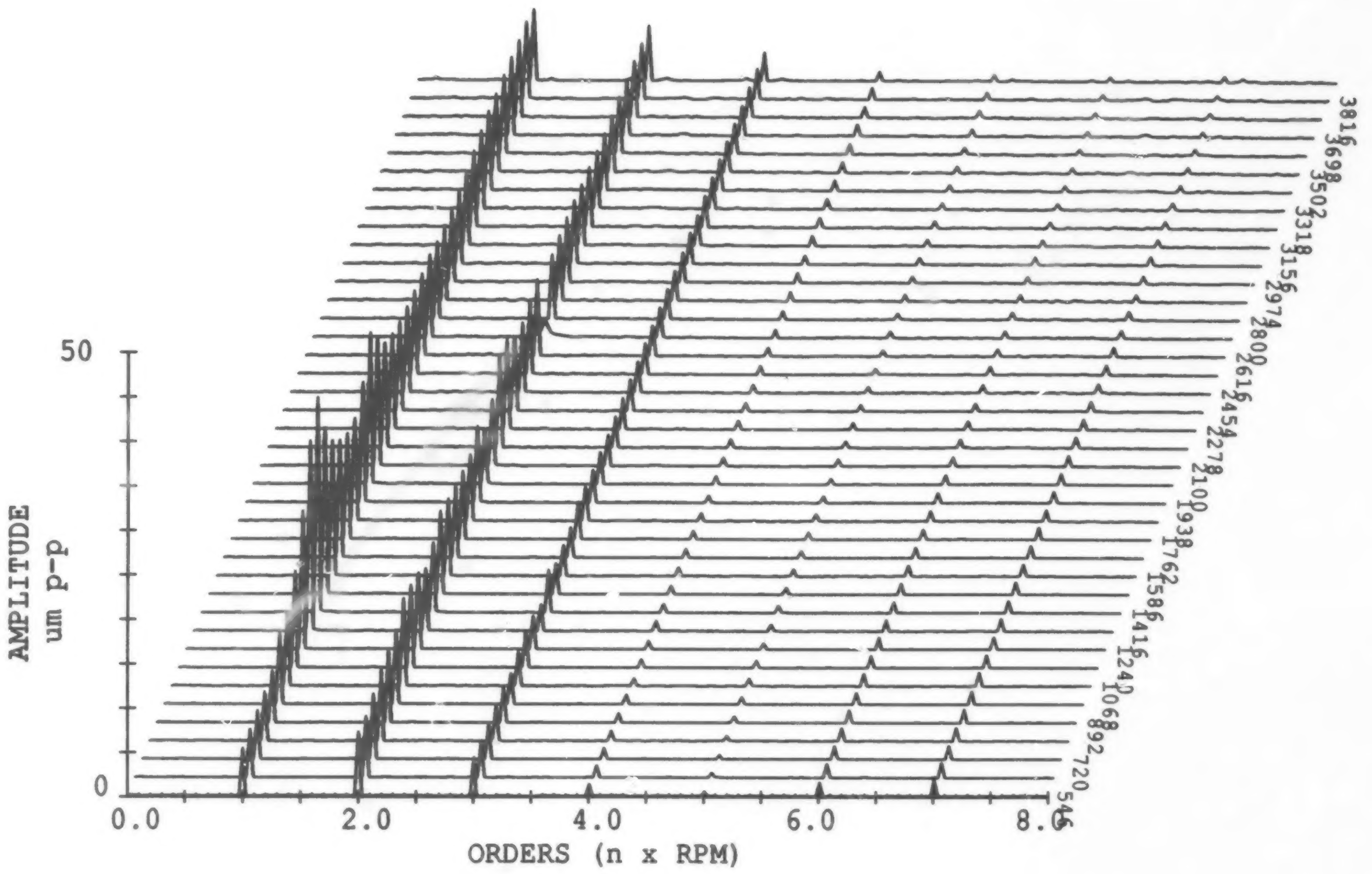


FIGURE 167

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 7 Inboard Brg. Shaft Displacement Y-Axis

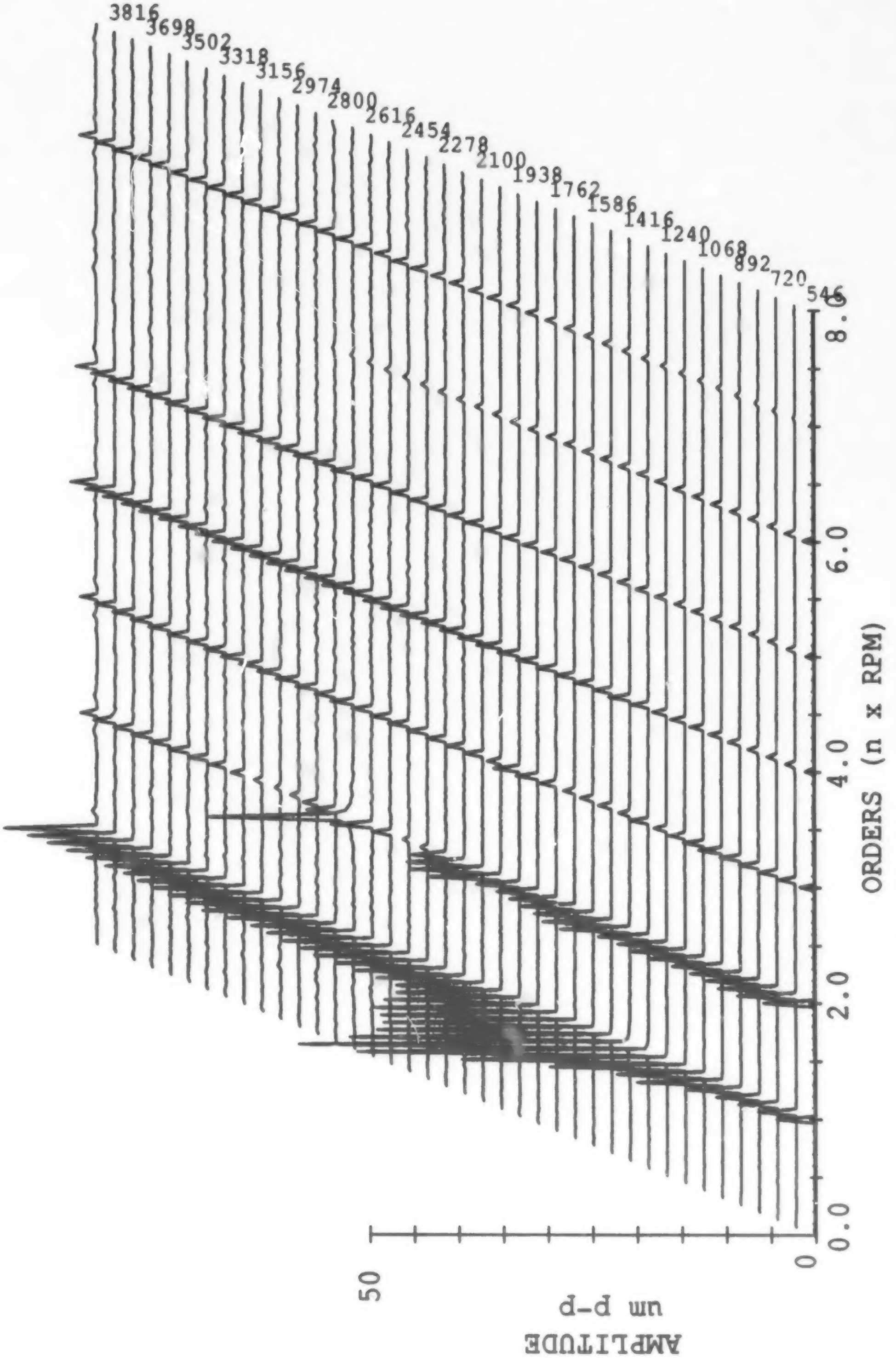


FIGURE 168

Darlington GS Standby Generator #3
AC Generator

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 8 Inboard Brg. Shaft Displacement X-Axis

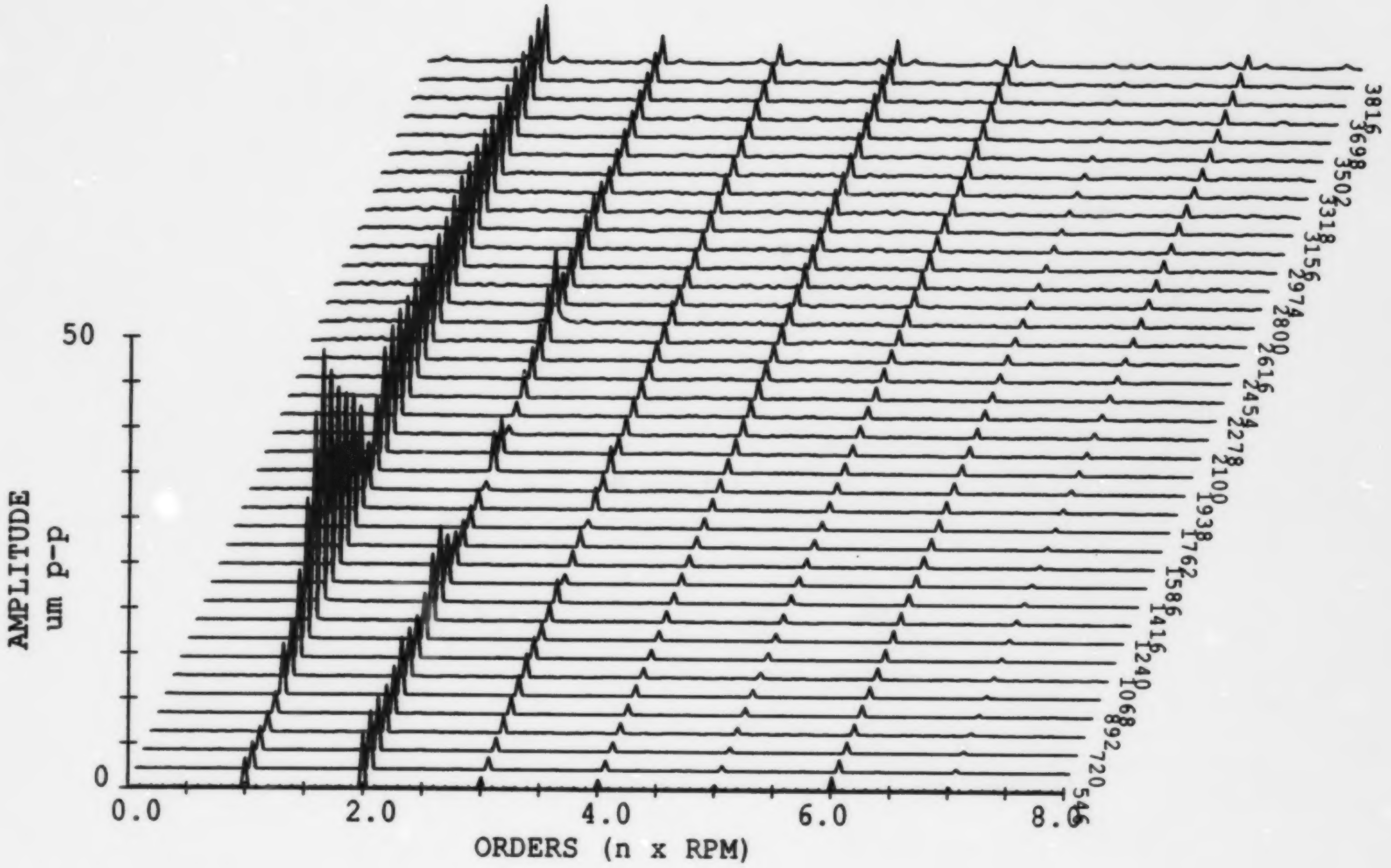
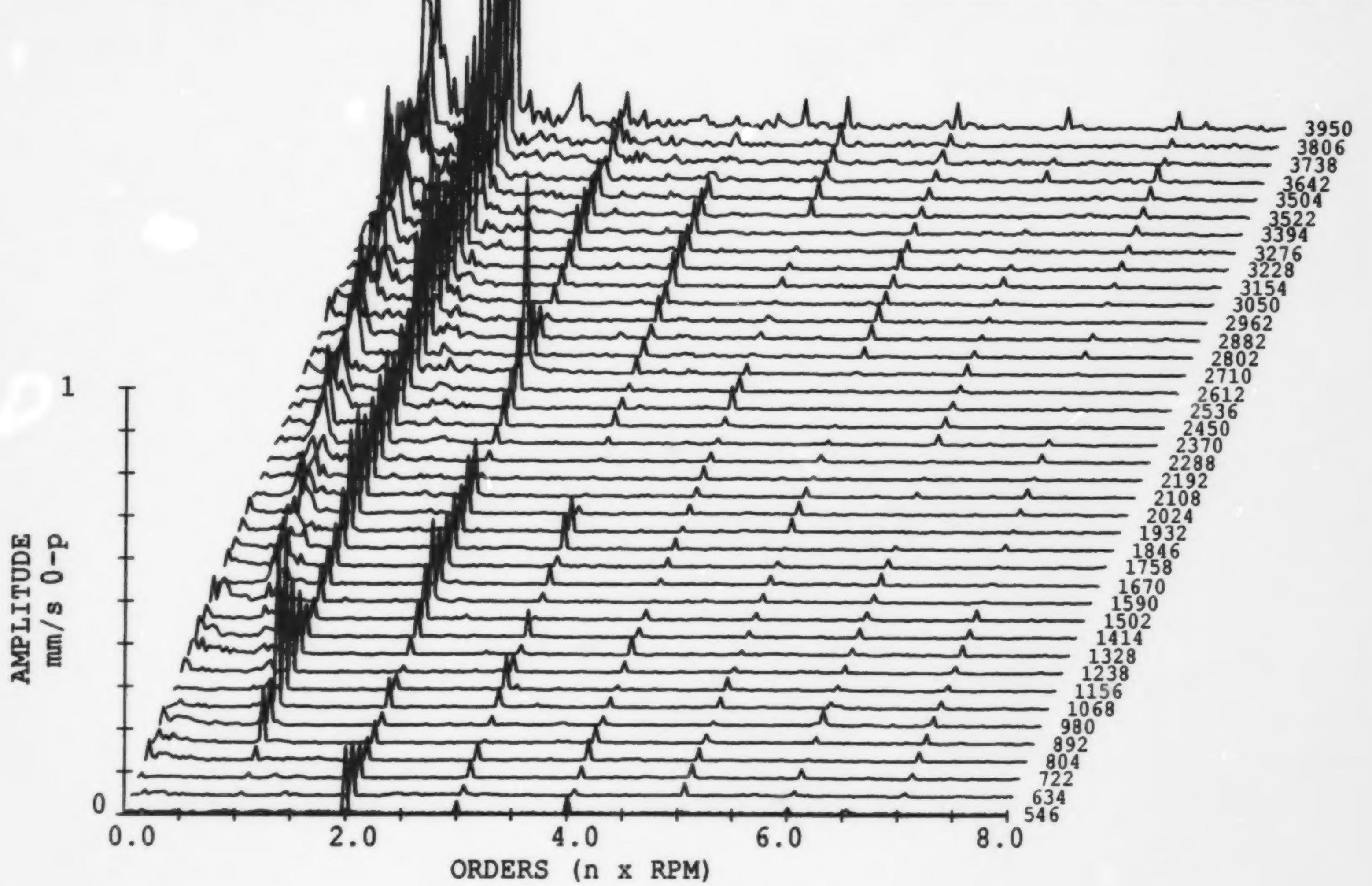


FIGURE 169



Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 2 Inboard Brg. Casing Velocity X-Axis

FIGURE 170

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 1 Inboard Brg. Casing Velocity Y-Axis

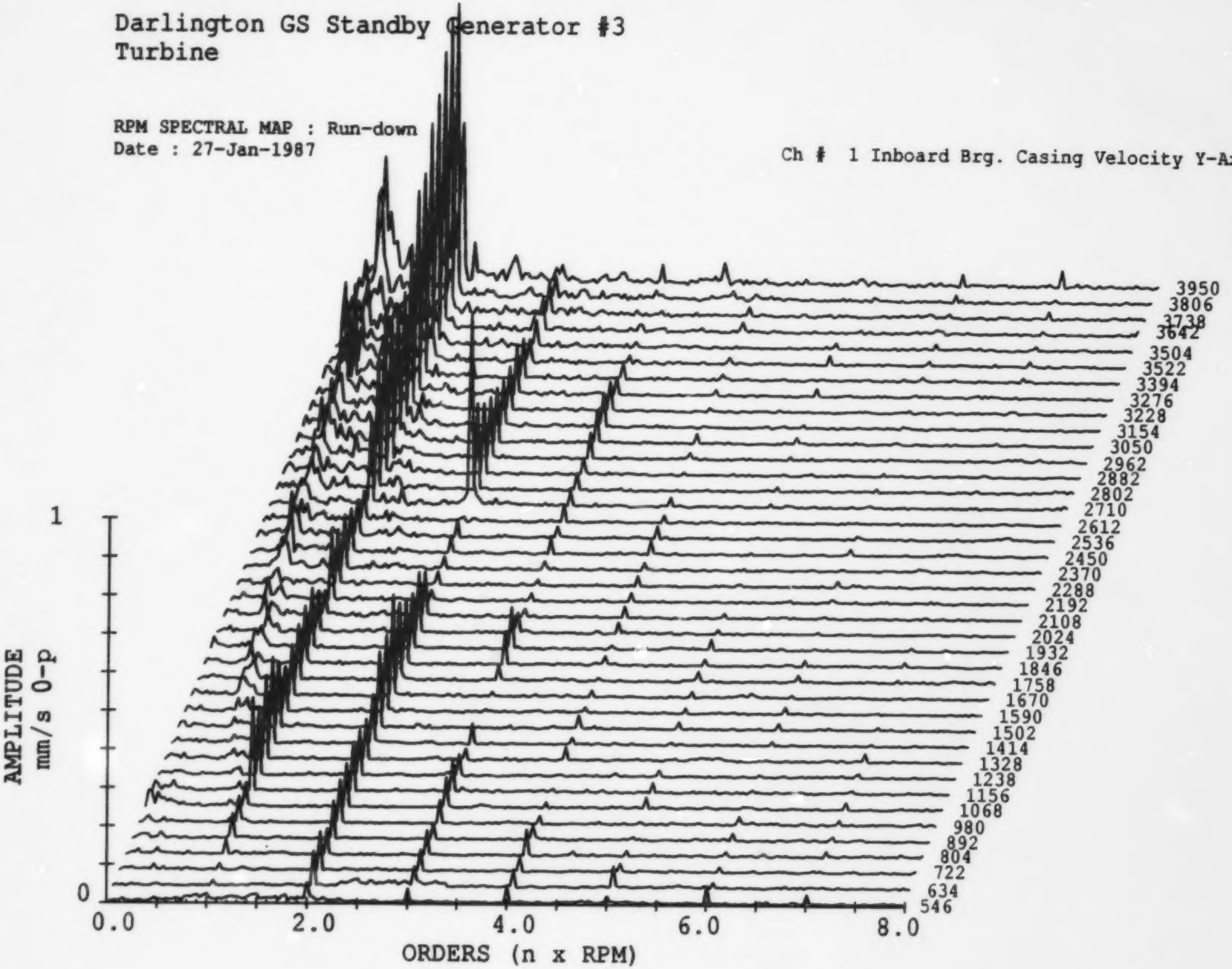


FIGURE 171

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 3 Inboard Brg. Casing Velocity Azial

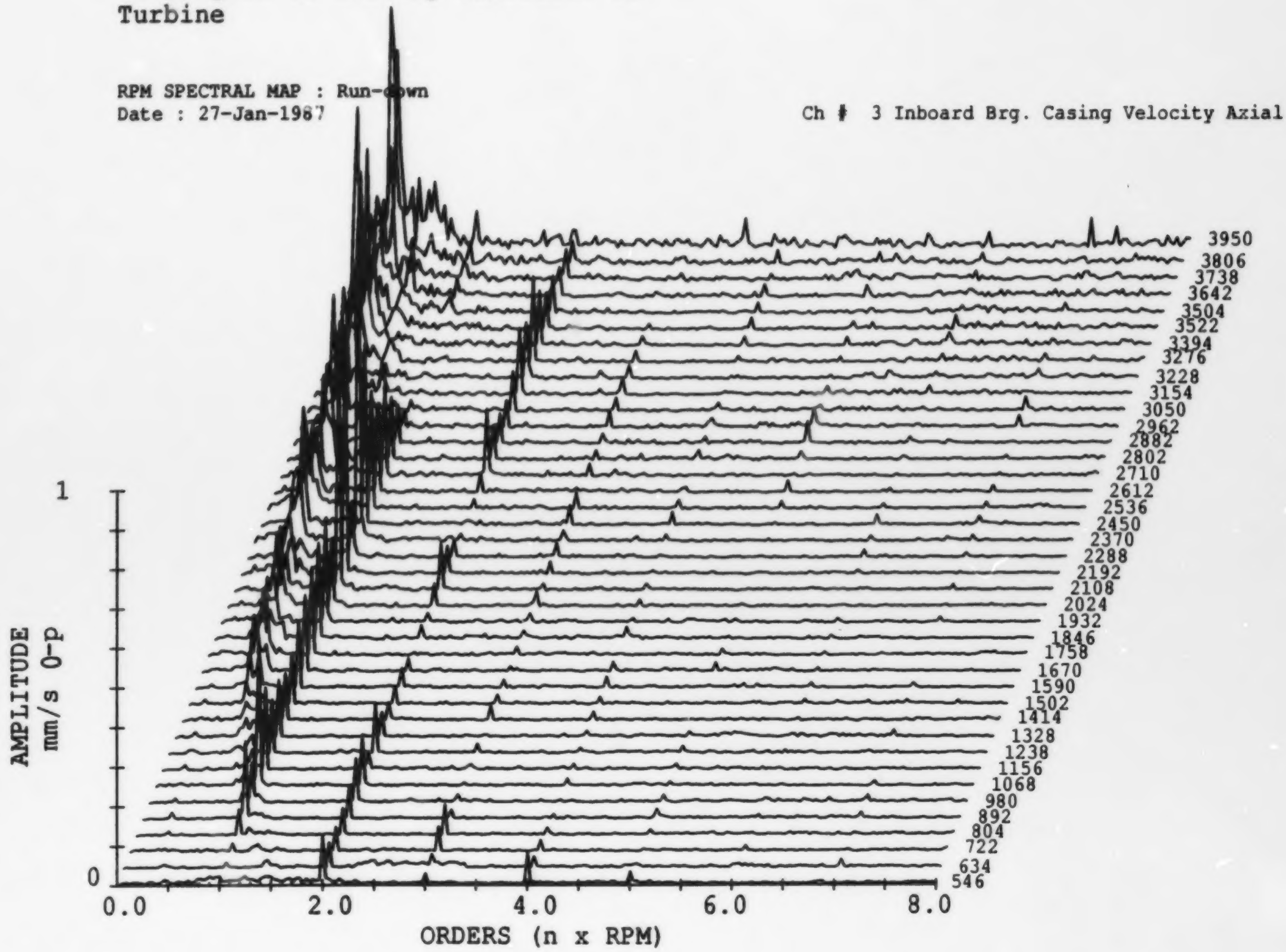


FIGURE 172

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 6 Inboard Brg. Shaft Displacement X-Axis

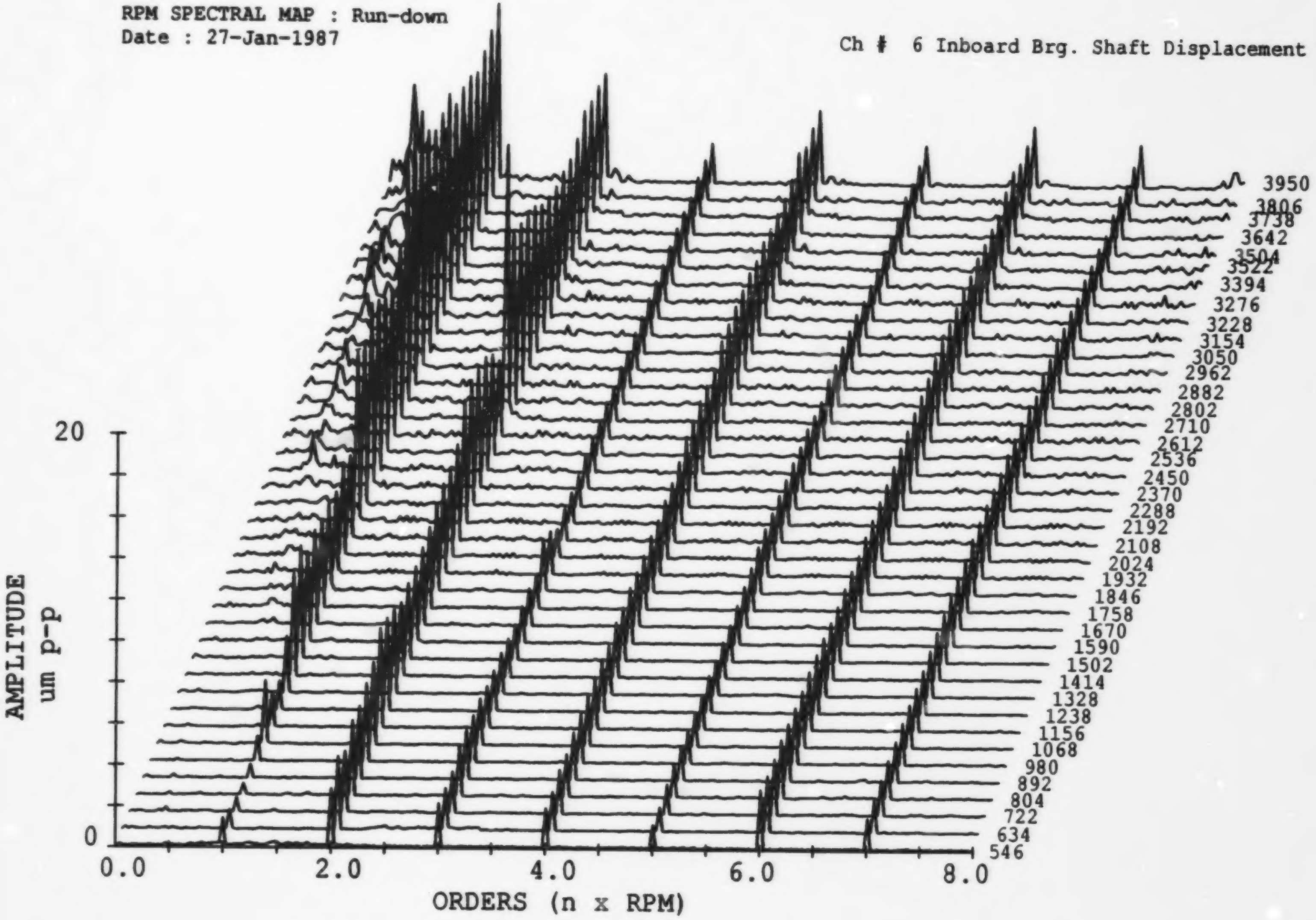


FIGURE 173

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 7 Inboard Brg. Shaft Displacement Y-Axis

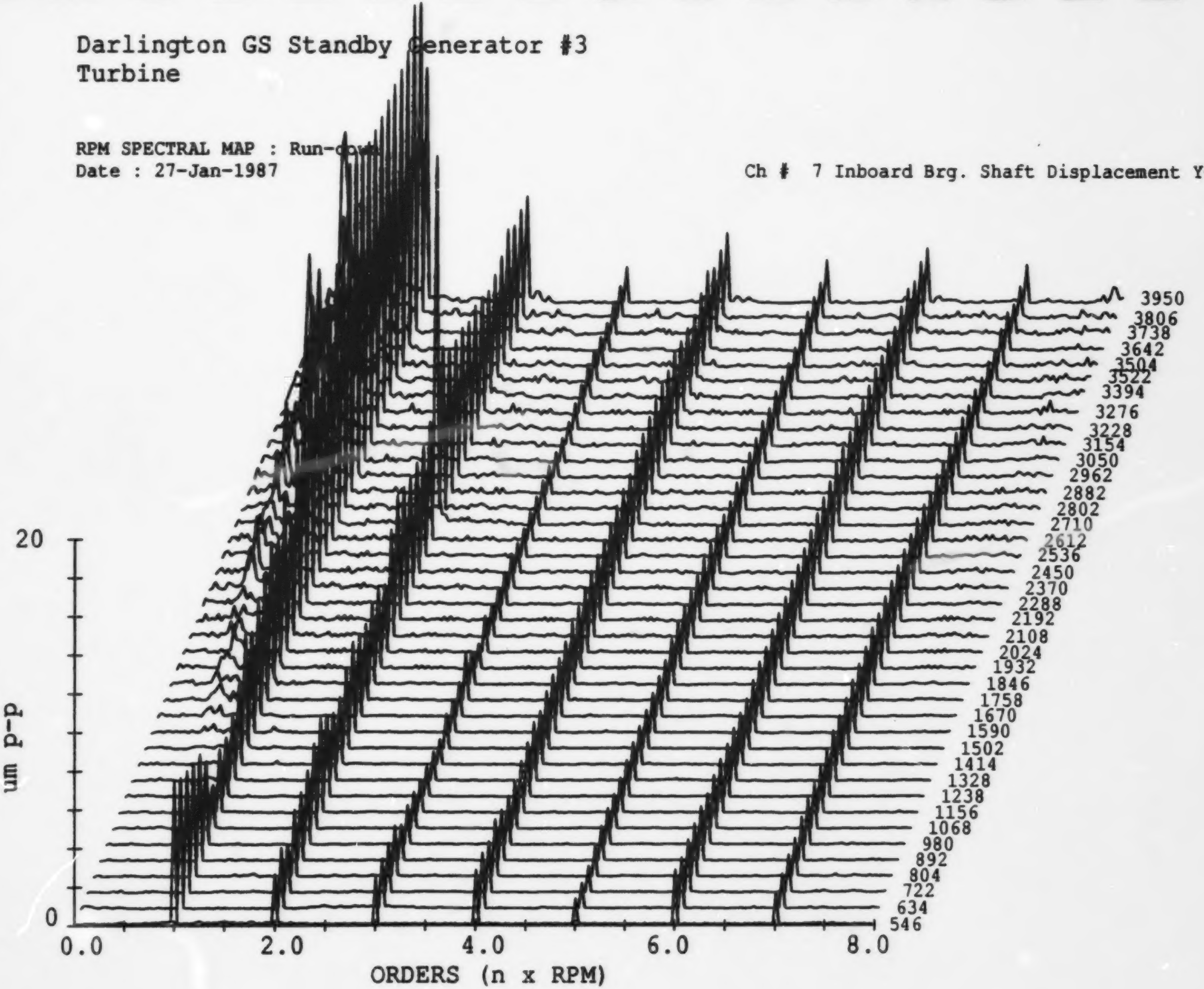


FIGURE 174

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 8 Outboard Brg. Shaft Displacement X-Axis

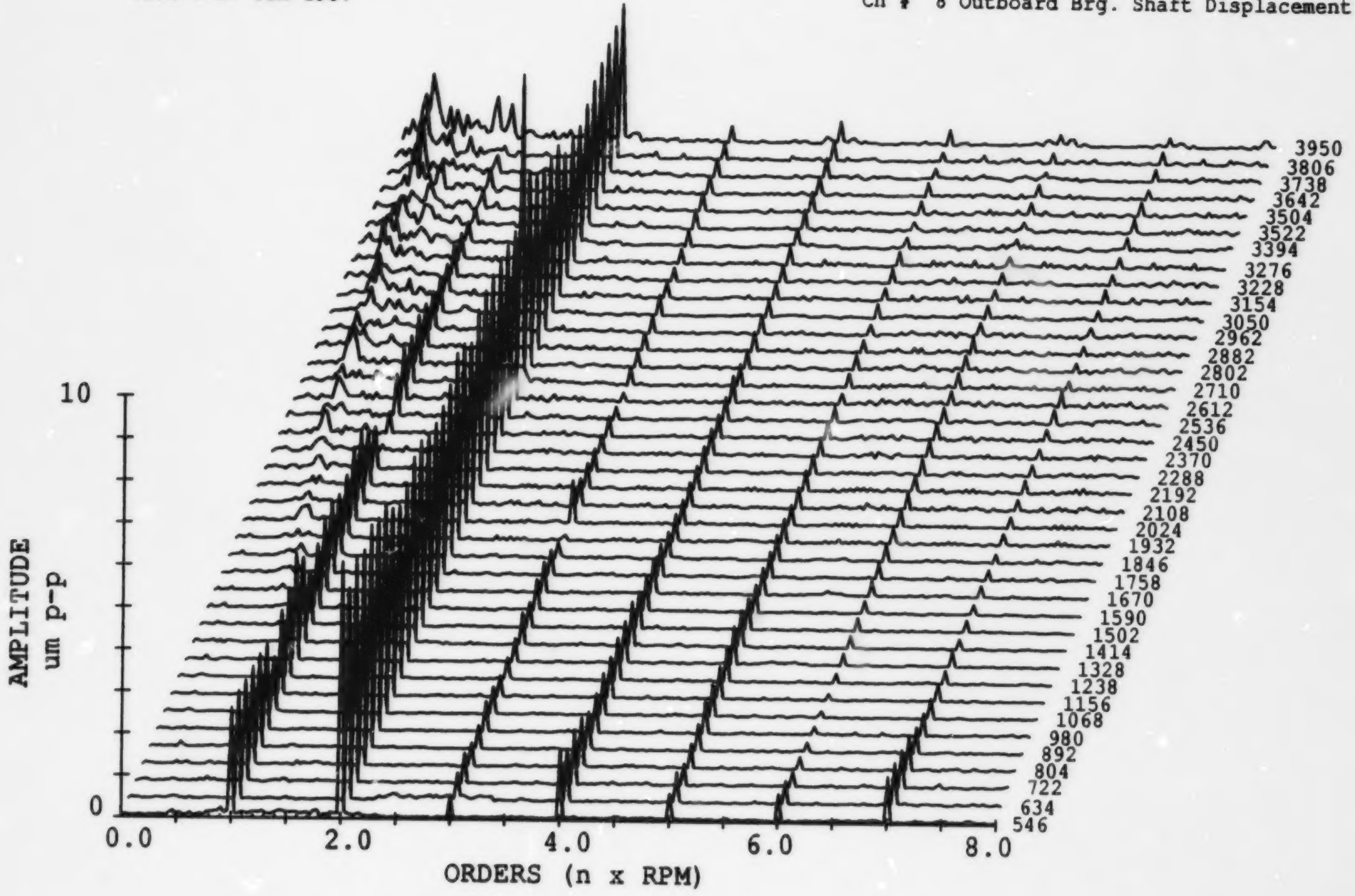


FIGURE 175

Darlington GS Standby Generator #3
Turbine

RPM SPECTRAL MAP : Run-down
Date : 27-Jan-1987

Ch # 9 Outboard Brg. Shaft Displacement Y-Axis

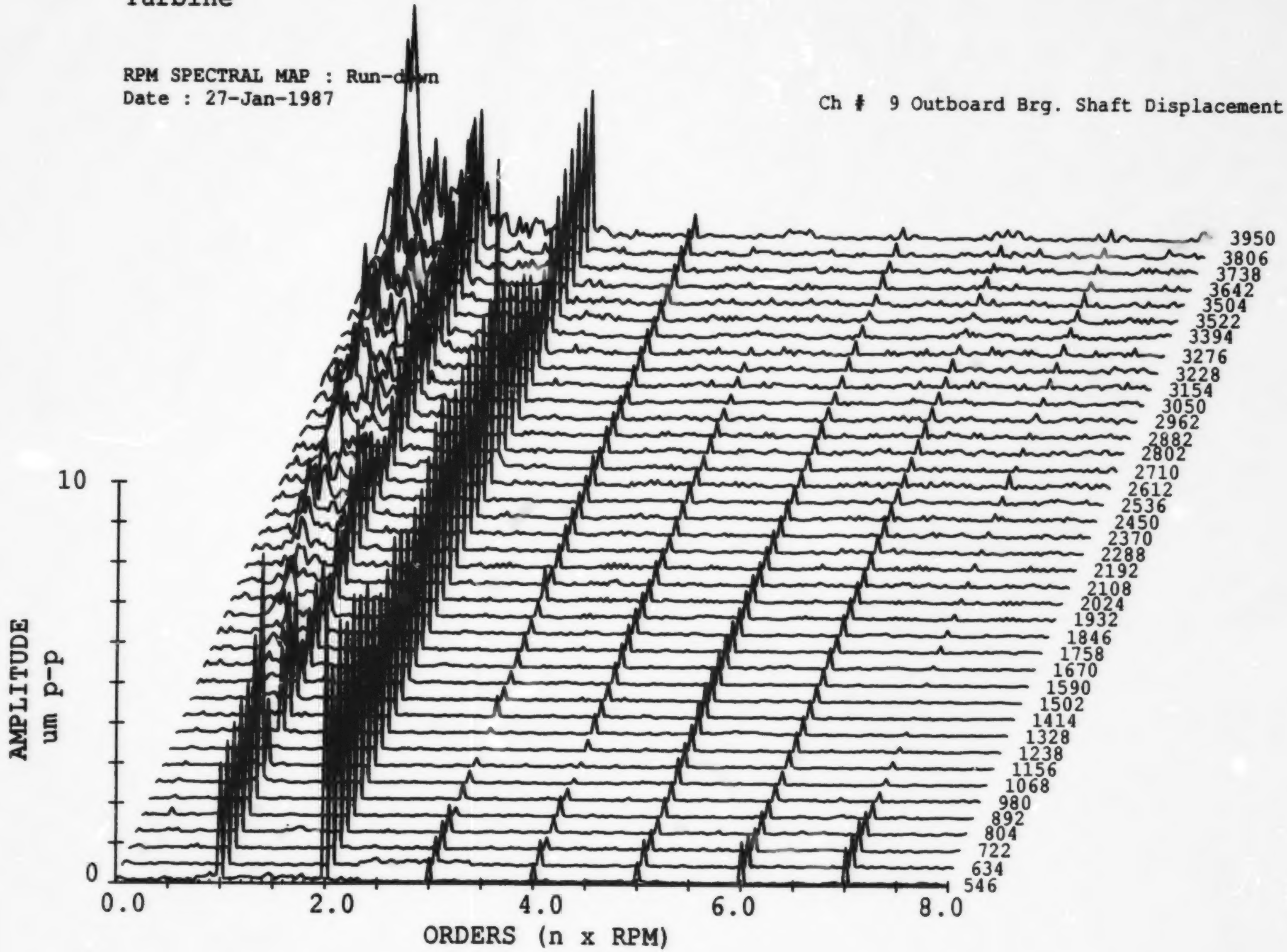
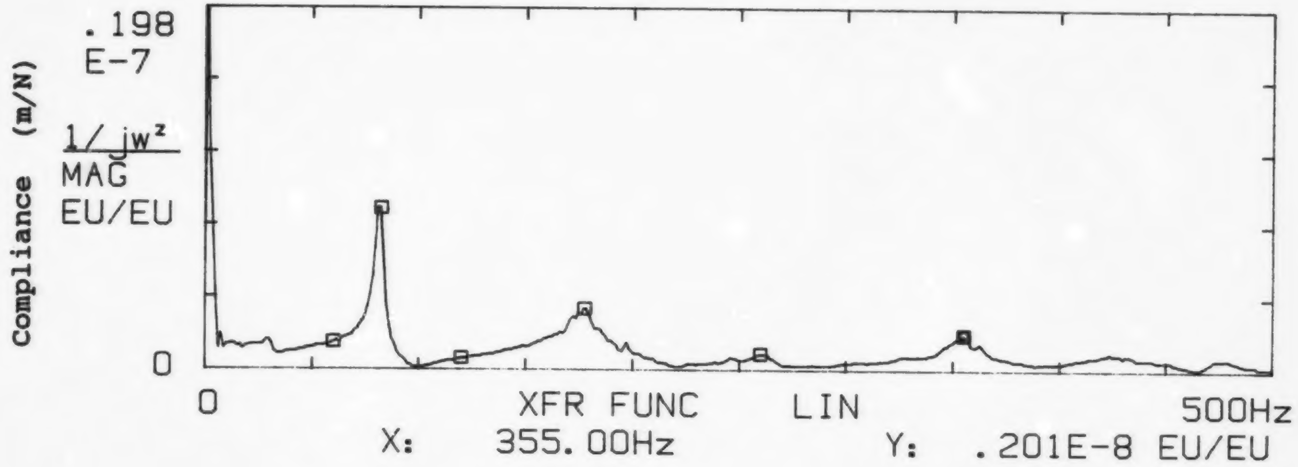


FIGURE 176

DARLINGTON GS 'A' STANDBY GENERATOR #3 - AC GENERATOR OUTBOARD BEARING CASING COMPLIANCE TRANSFER FUNCTION (HORIZONTAL DIRECTION)

```
DARLINGTON NGS SG#3 GEN OB HORIZ IMPACT 28/1/87    00:27
 100kHz  A:AC/ 50V   B:AC/ 50V    INST     0/16     DUAL 1k

                XFER FUNC  MAG - PH
 1       60.00Hz       .158E-8 EU/EU   177.6 deg
 2       82.50         .890E-8          78.5
 3      120.00         .696E-9         167.6
 4      177.50         .344E-8          98.3
 5      260.00         .948E-9          75.9
 6      355.00         .201E-8          71.1
 7
 8
 9
10
```



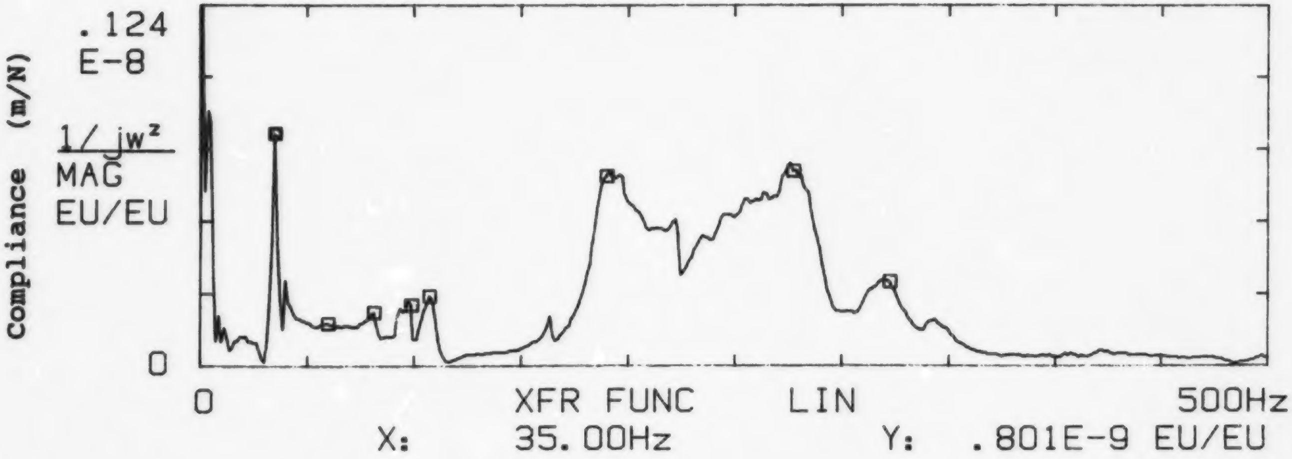
00:10

FIGURE 177

DARLINGTON GS 'A' STANDBY GENERATOR #3 - AC GENERATOR OUTBOARD BEARING CASING COMPLIANCE TRANSFER FUNCTION (VERTICAL DIRECTION)

```
DARLINGTON NGS SG#3 GEN OB VERT   IMPACT 28/1/87    00:30
 100kHz A:AC/ 50V  B:AC/ 50V    INST     0/16     DUAL 1k

                   XFER FUNC  MAG - PH
 1        35.00Hz          .801E-9 EU/EU     56.9 deg
 2        60.00            .148E-9           -4.5
 3        81.25            .187E-9          -25.2
 4        98.75            .217E-9          -58.9
 5       107.50            .245E-9          -72.5
 6       190.00            .658E-9           52.4
 7       277.50            .669E-9          -77.2
 8       322.50            .291E-9         -103.5
 9
10
```



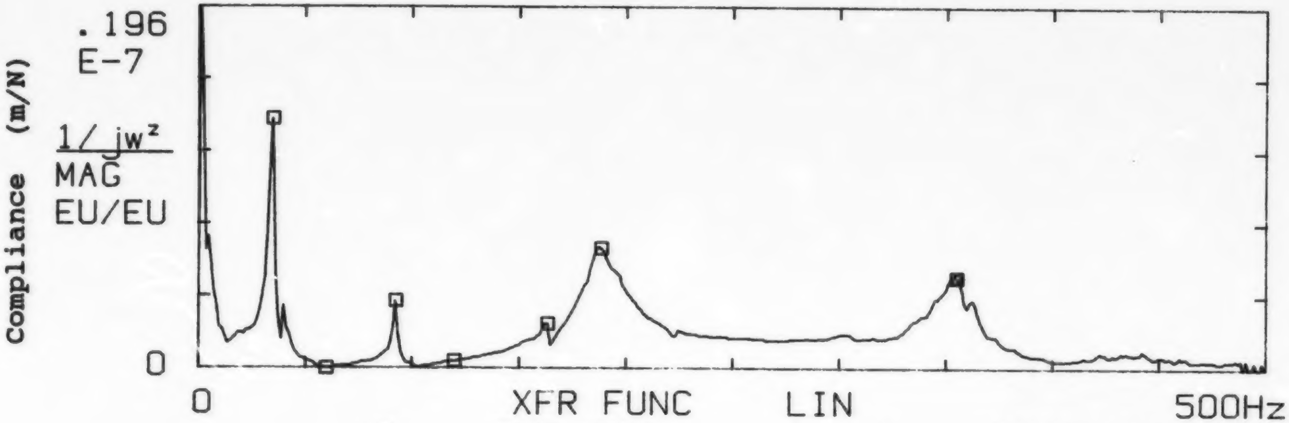
00:15

FIGURE 178

DARLINGTON GS 'A' STANDBY GENERATOR #3 - AC GENERATOR OUTBOARD BEARING CASING COMPLIANCE TRANSFER FUNCTION (AXIAL DIRECTION)

```
DARLINGTON NGS SG#3 GEN OB AXIAL IMPACT 28/1/87   00:45
 100kHz A:AC/ 50V  B:AC/ 50V   INST    0/16    DUAL 1k

                      XFER FUNC  MAG - PH
 1        35.00Hz          .136E-7 EU/EU  -120.5 deg
 2        60.00            .495E-10       -131.3
 3        92.50            .369E-8         -91.0
 4       120.00            .464E-9         -17.7
 5       163.75            .248E-8         -70.8
 6       188.75            .662E-8        -112.8
 7       355.00            .501E-8          72.9
 8
 9
10
```



```
X:    355.00Hz              Y:  .501E-8 EU/EU
```

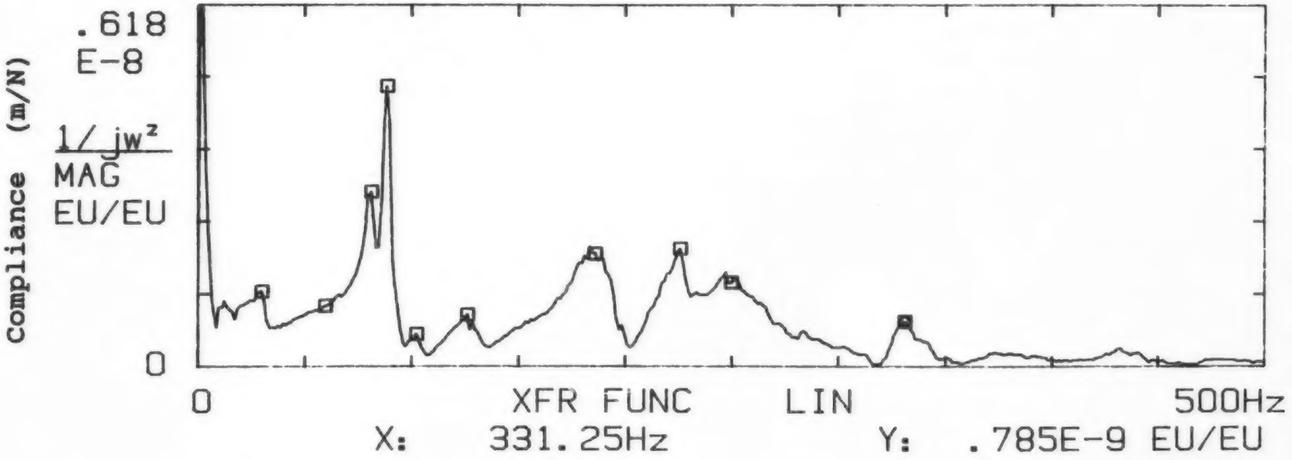
00:20

FIGURE 179
89-5

DARLINGTON GS 'A' STANDBY GENERATOR #3 - AC GENERATOR INBOARD BEARING CASING COMPLIANCE TRANSFER FUNCTION (HORIZONTAL DIRECTION)

```
DARLINGTON NGS SG#3 GEN IB HORIZ IMPACT 28/1/87   00:52
  500Hz A:AC/ 50V  B:AC/ 50V    INST     0/16    DUAL 1k

                    XFER FUNC  MAG - PH
 1         30.00Hz         .131E-8 EU/EU    153.6 deg
 2         60.00           .105E-8          176.8
 3         81.25           .301E-8          134.9
 4         88.75           .480E-8           91.1
 5        102.50           .578E-9           83.7
 6        126.25           .899E-9          124.4
 7        186.25           .194E-8           89.2
 8        226.25           .205E-8           64.1
 9        250.00           .146E-8           31.0
10        331.25           .785E-9           64.5
```



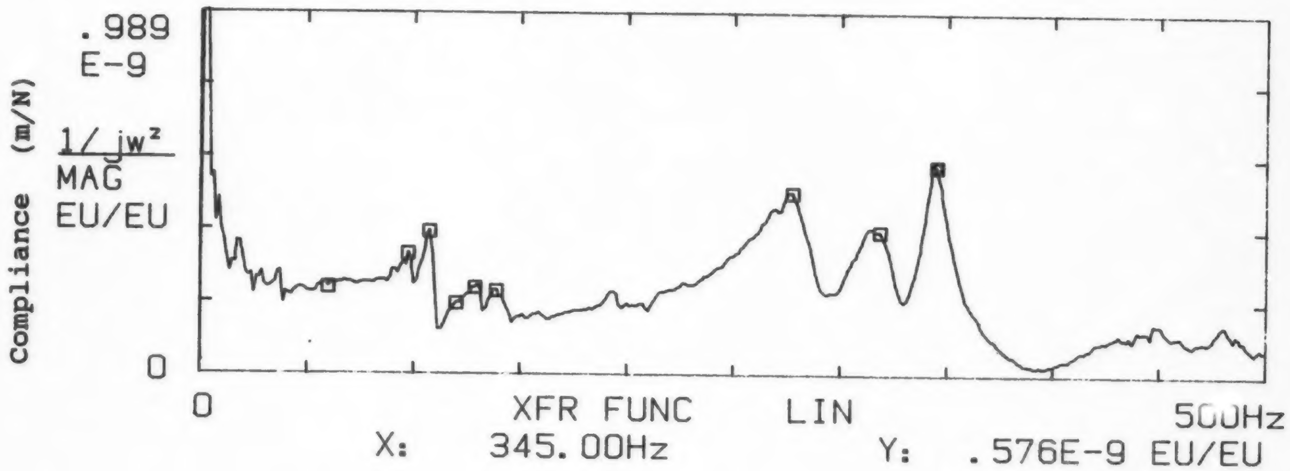
00:24

FIGURE 180
89-5

DARLINGTON GS 'A' STANDBY GENERATOR #3 - AC GENERATOR INBOARD BEARING CASING COMPLIANCE TRANSFER FUNCTION (VERTICAL DIRECTION)

```
DARLINGTON NGS SG#3 GEN IB VERT  IMPACT 28/1/87    00:55
 500Hz A:AC/ 50V  B:AC/ 50V   INST     0/16    DUAL 1k

                    XFER FUNC  MAG - PH
1       60.00Hz          .240E-9 EU/EU     -6.7 deg
2        97.50           .332E-9          -23.2
3       107.50           .391E-9          -50.6
4       120.00           .196E-9          -21.9
5       128.75           .241E-9          -29.6
6       138.75           .230E-9          -37.6
7       277.50           .501E-9          -75.0
8       318.75           .394E-9         -103.1
9       345.00           .576E-9         -124.5
10
```



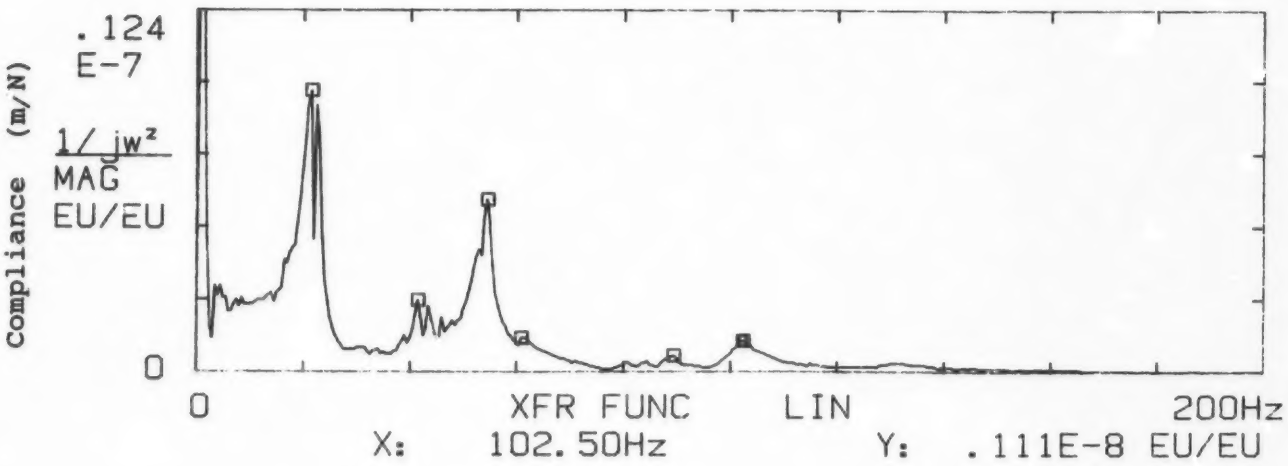
00:30

FIGURE 181

DARLINGTON GS 'A' STANDBY GENERATOR #3 - POWER TURBINE INBOARD BEARING PEDESTAL COMPLIANCE TRANSFER FUNCTION (HORIZONTAL DIRECTION)

```
DARLINGTON NGS SG#3 PWR TURB IB HOR IMPACT 28/1/8701:04
 500Hz A:AC/ 50V  B:AC/ 50V   INST    0/16    DUAL 1k

                    XFER FUNC  MAG - PH
1        21.50Hz         .967E-8 EU/EU   -91.1 deg
2        41.50           .251E-8          -55.5
3        54.50           .595E-8         -125.4
4        61.00           .123E-8         -147.6
5        89.50           .583E-9         -122.9
6       102.50           .111E-8         -110.2
7
8
9
10
```



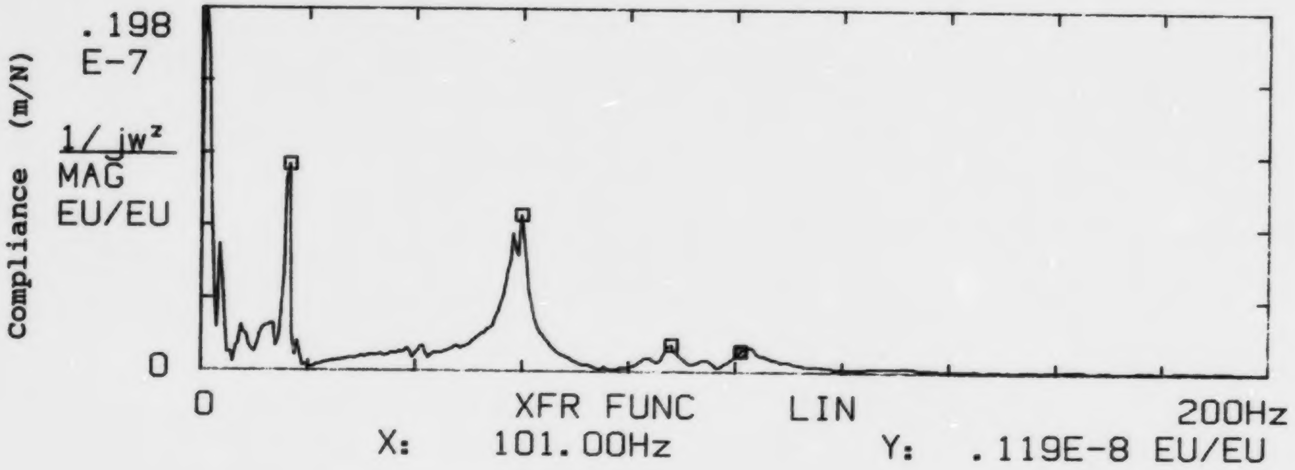
00:38

FIGURE 182
89-5

DARLINGTON GS 'A' STANDBY GENERATOR #3 - POWER TURBINE INBOARD BEARING PEDESTAL COMPLIANCE TRANSFER FUNCTION (VERTICAL DIRECTION)

```
DARLINGTON NGS SG#3 PWR TURB IB VER IMPACT 28/1/8701:14
 500Hz A:AC/ 50V  B:AC/ 50V   INST    0/16    DUAL 1k

                    XFER FUNC  MAG - PH
 1       16.50Hz         .114E-7 EU/EU  -141.2 deg
 2       60.00           .857E-8         -97.8
 3       88.00           .150E-8         -89.9
 4      101.00           .119E-8         -76.4
 5
 6
 7
 8
 9
10
```



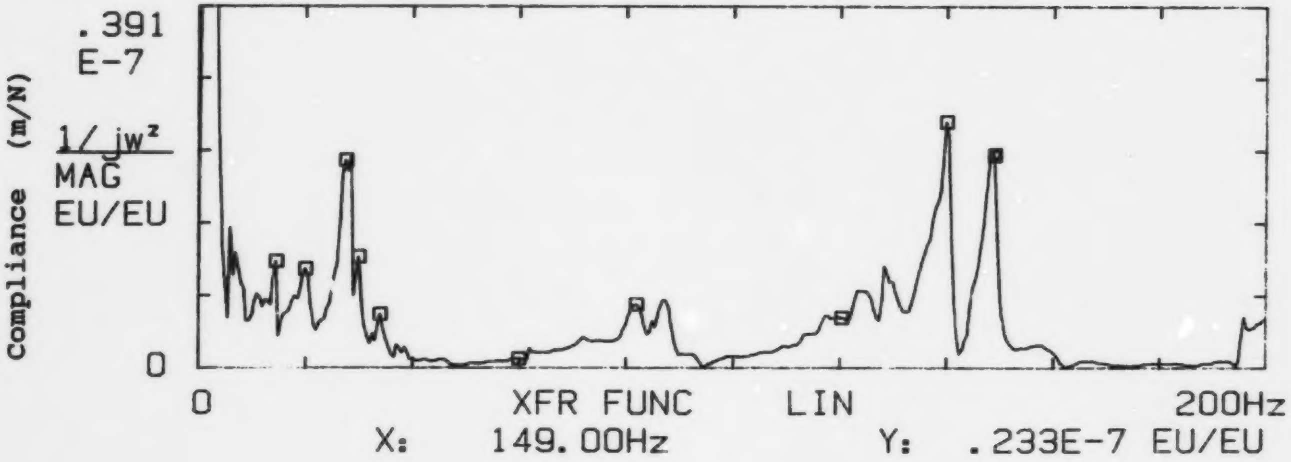
00:41

FIGURE 183
89-5

DARLINGTON GS 'A' STANDBY GENERATOR #3 - POWER TURBINE OUTBOARD BEARING PEDESTAL COMPLIANCE TRANSFER FUNCTION (HORIZONTAL DIRECTION)

```
DARLINGTON NGS SG#3 PWR TURB OB HOR IMPACT 28/1/8702:37
  200Hz A:AC/ 50V  B:AC/ 50V    INST     0/16     DUAL 1k

                   XFER FUNC  MAG - PH
 1         14.50Hz       .117E-7 EU/EU   -74.7 deg
 2         20.00         .109E-7          -39.6
 3         27.50         .226E-7          -74.8
 4         30.00         .122E-7         -134.4
 5         34.00         .595E-8         -140.4
 6         60.00         .115E-8          -10.6
 7         82.00         .705E-8          -58.0
 8        120.50         .562E-8          -54.0
 9        140.00         .268E-7         -170.3
10        149.00         .233E-7          115.4
```



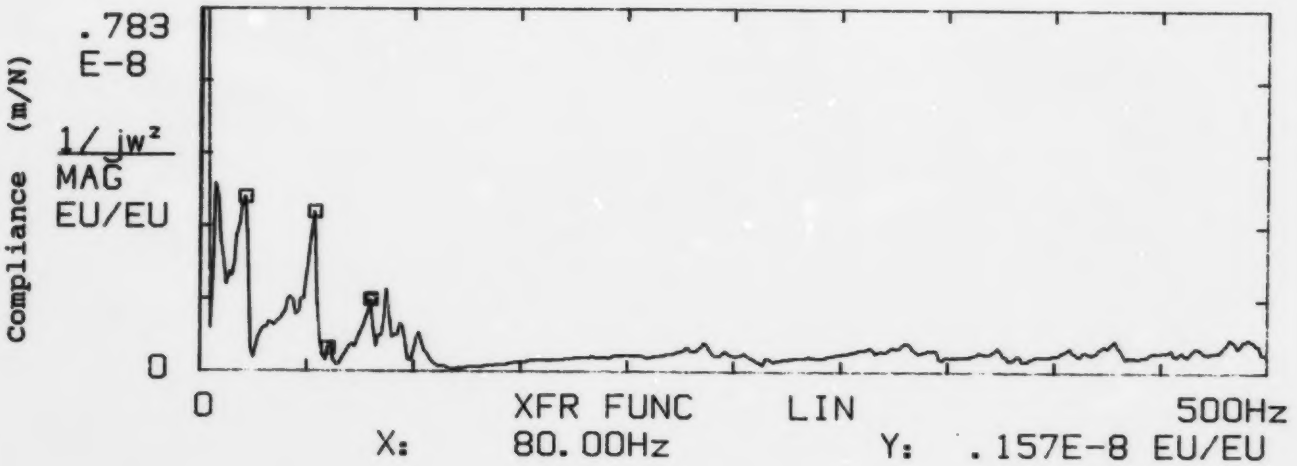
00:45

FIGURE 184
89-5

DARLINGTON GS 'A' STANDBY GENERATOR #3 - POWER TURBINE SKID INBOARD END COMPLIANCE TRANSFER FUNCTION (HORIZONTAL DIRECTION)

```
DARLINGTON NGS SG#3 SKID HOR        RVSMPACT 28/1/8702:49
  200Hz A:AC/ 50V  B:AC/ 50V    INST     0/16     DUAL 1k

                        XFER FUNC  MAG - PH
1         21.25Hz          .379E-8 EU/EU    -92.6 deg
2         53.75            .347E-8         -121.6
3         60.00            .530E-9          -71.0
4         80.00            .157E-8          -62.6
5
6
7
8
9
10
```



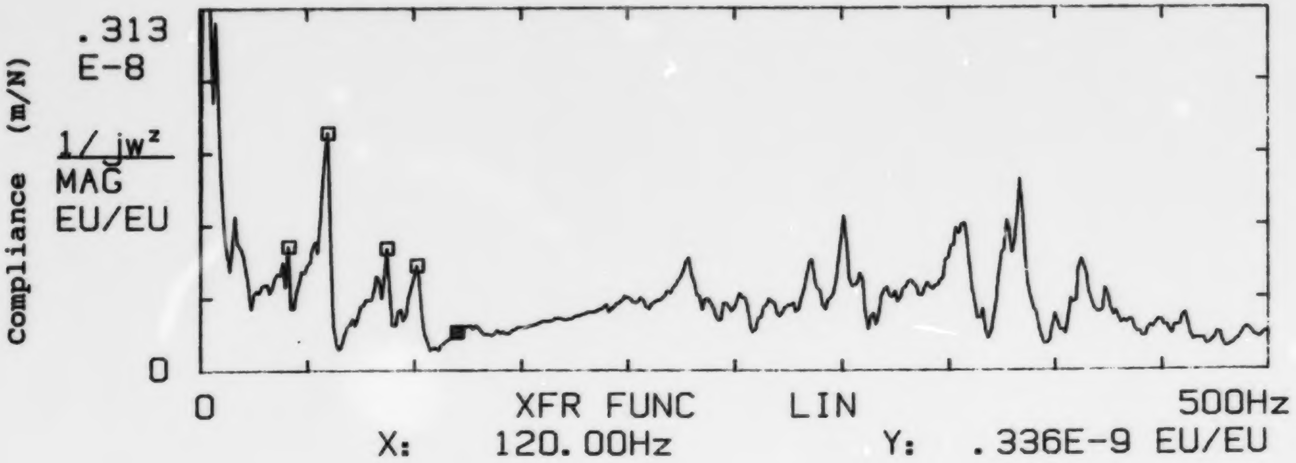
00:54

FIGURE 185
89-5

DARLINGTON GS 'A' STANDBY GENERATOR #3 - POWER TURBINE SKID INBOARD END
COMPLIANCE TRANSFER FUNCTION (VERTICAL DIRECTION)

```
DARLINGTON NGS SG#3 SKID VERT          IMPACT 28/1/8702:52
  500Hz A:AC/ 50V  B:AC/ 50V    INST     0/16     DUAL 1k

                   XFER FUNC  MAG - PH
1        41.25Hz          .108E-8 EU/EU    -27.5 deg
2        60.00            .206E-8          -86.0
3        87.50            .107E-8          -53.6
4       101.25            .916E-9          -66.1
5       120.00            .336E-9          -17.4
6
7
8
9
10
```



00:56

FIGURE 186
89-5

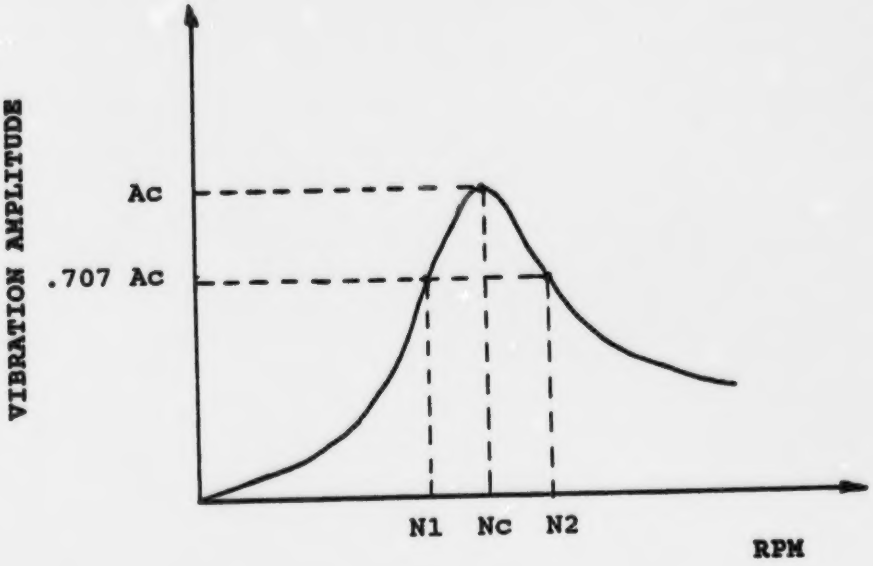
APPENDIX A

COMPENSATION

A Bode plot will be distorted if the signal from the displacement transducer includes any appreciable amount of shaft bow or runout (any deviation in the observed shaft surface which produces a transducer output which is not related to shaft motion). Both shaft bow and runout will create an initial vector or offset in the phase and amplitude portions of the Bode plot. As the shaft speed changes, the bow or runout value (presumably a constant) vectorially combines with true shaft motion to produce the total signal sensed by the transducer. If the bow or runout is a significant portion of the total signal, the appearance of the Bode plot can be greatly altered. These alterations or distortions may include an amplitude peak and phase shift well removed from the actual critical speed, dips in amplitude rather than peaks, or no response in extreme cases.

To circumvent this problem, the displacement transducer signal at a slow shaft speed is obtained and stored. As the shaft speed changes, the slowroll displacement signal can be subtracted from the total displacement signal to yield a signal compensated for shaft bow and runout.

APPENDIX B
DETERMINING AMPLIFICATION FACTORS



Nc = Rotor critical centre frequency (cycles/minute)
N1 = Initial (lesser) speed at 0.707 x peak amplitude (critical)
N2 = Final (greater) speed at 0.707 x peak amplitude (critical)
Ac = Amplitude at Nc

AF = Amplification Factor = $\frac{Nc}{N2 - N1}$